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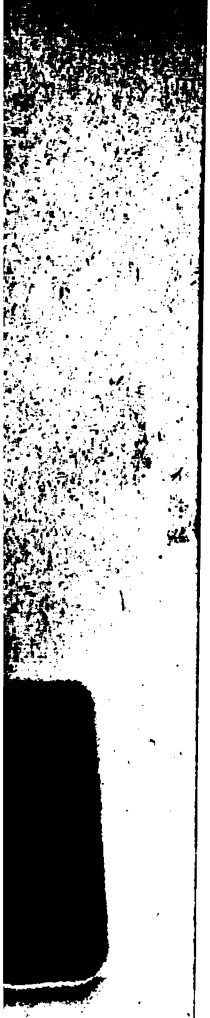

SECOND REPORT

OF AN

INVESTIGATION

OF THE

RIVERS OF OHIO

As Sources of

Public Water Supplies.

BY THE OHIO STATE BOARD OF HEALTH.

1899.

Reprinted from the Thirteenth Annual Report of the Ohio State Board of Health.

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The State Board of Health.

SECOND REPORT UPON THE EXAMINATION OF SOURCES OF WATER SUPPLIES.

The Board has recently published in separate form a preliminary report upon the "Examination of Sources of Water Supplies," to which attention was called in the last report. The investigation last year was confined to the Scioto, Olentangy and Mahoning rivers. During the present year the Board has had under observation the Maumee and San dusky rivers and their branches. Stations for observation were established as follows: On the Maumee river, Findlay, Lima, Ft. Wayne, Indiana, Defiance, Napoleon and Toledo. On the Sandusky river: Crestline, Bucyrus, Upper Sandusky, Tiffin, Fremont and Sandusky. Chemical and bacteriological examinations have been made monthly, commencing in June, of these streams above and below the stations named above. Arrangements have been made for the daily measurement of these streams, with the coöperation of the Division of Hydrography of the United States Geological Survey. Daily measurements are also being made of the Scioto and Olentangy rivers. The stations are located as follows: On the Sandusky, at Mexico and Fremont; on the Maumee, at Waterville; on the Olentangy, the Fifth avenue bridge, Columbus; and on the Scioto, the Grandview bridge, Columbus.

Accurate determinations of the daily volume of flow of our Ohio streams will afford information of much value, affecting sanitary as well as other interests. These observations are to be continued for several years, and, with others, will afford a basis in connection with rainfalls to compute the flowage of all our streams.

Further on will be found a detailed report of the results of the chemical and bacteriological examinations, and of the various sources of pollution upon the two watersheds under examination, with other matters of interest bearing upon the condition of the two streams—the Sandusky and Maumee rivers.

SUMMARY.

SANDUSKY RIVER.

The results of examinations of samples of river water, and the report of the engineer of his inspection of the watershed, show there is a serious pollution of this river at many points along its course. Beginning at Crestline we find one of the upper branches of the river badly polluted by the sewage of that city. Complaint is already made of the nuisance thus created, and the near future will doubtless witness demands upon Crestline to care for its sewage in a proper manner.

At Bucyrus we find an exceedingly bad state of affairs. The river in the village, and for some distance below, during dry weather is a foul, stinking stream; an unbearable nuisance, outraging many people compelled to live within its disease-breeding influence. The State Board of Health has refused to allow Bucyrus to construct additional sewers to discharge into the river, but the city should be compelled, and without delay, to remedy this evil by the construction of sewage purification works.

The public water supply of Bucyrus is badly polluted, and fortunately is held in such low esteem as to be but little, if at all, used for domestic purposes. The filters in use afford no adequate purification of the supply.

At Upper Sandusky the river, which has not recovered from its gross pollution at Bucyrus, is again used to receive sewage. While the conditions here are not nearly so bad as at Bucyrus, any increase in the amount of sewage of Upper Sandusky will create a serious nuisance.

The water supply of Upper Sandusky is in part derived from the river, 24 miles below Bucyrus, the point of maximum pollution. That this is a safe supply no one would maintain. The city should at once begin a systematic search for additional ground water, and failing to find it, should make provision for proper purification of all river water used.

Tiffin, the largest city directly upon the Sandusky river, is thickly built up along both banks of the river. Sewage is discharged into the river at various points within city limits. A low dam just below the city maintains, most of the time, a shallow depth of water over the river bed, which is quite wide at this point. The pollution of the river has been the cause of much complaint, though this has been less for the last two years, greater attention during this time having been paid to keeping

a fair depth of water over the river bed. The time cannot be far distant when Tiffin will be forced into giving attention to the question of sewage purification.

The water supply of Tiffin is taken in part from the river. While there are no nearby sources of pollution of the river at this point, the examinations show that it is far from a desirable supply. The Water Works Company's claim that they can, by changing their pumping arrangements, furnish an adequate quantity from their deep wells, should be put to the test at once.

Fremont looks to the Sandusky river for a part of its water supply. Being but 23 miles below Tiffin, a city of 14,000 people, and discharging all its sewage into this river, the supply cannot be regarded as a safe one. Evidence of this sewage pollution is clearly given by the chemical and bacteriological examinations of the river water at this point. Fremont should persevere in her attempt to obtain the entire water supply from deep wells.

The conditions threatening the water supply of Sandusky deserve serious consideration. This city, of over 20,000 people, is built along Sandusky bay. The bay receives whatever filth remains in the Sandusky river, poured into it by the cities along its course, as noted above In addition it receives all of the sewage of Sandusky. The bay is shallow, and at the water works crib, 1,200 feet from the shore line, is only seven feet deep. The lake currents, when the wind blows from a certain point, carry sewage polluted water to the intake. The supply can scarcely escape pollution at times. Sandusky should go to Lake Erie, beyond sources of pollution, for a new water supply, or should adequately purify the present supply.

MAUMEE RIVER.

The Maumee river is less seriously polluted than the Sandusky, although some of its tributaries have become very foul in dry weather.

Perhaps the worst place to be found is at Findlay. This is a city of about 20,000 persons, located on the Blanchard river. One of the main sewers discharges into the river near the central part of the city, and in summer produces a pollution of the river which has already caused suits to be brought for damages. A part of the sewage goes into Eagle creek, which is also badly polluted. The conditions at Findlay demand early attention. The river flow is much too small to receive the sewage of the city, and sewage disposal works should be constructed without delay.

The water supply of Findlay is taken from the Blanchard river, with some attempt at purification. The supply is not of very good quality, and better methods of purification are necessary.

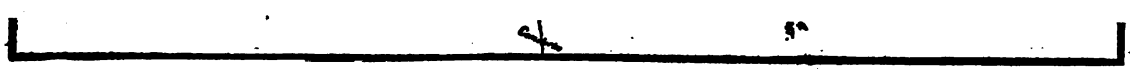
Lima, on the Ottawa river, is another example of attempting to utilize a small stream to dispose of the sewage of many people. The conditions here have been somewhat improved by cutting a channel or open ditch in the stony bottom of the river, which confines the sewage, in low water, and carries it away from the city before decomposition has progressed very far. The river, however, is in bad condition, and sewage disposal works will eventually be required.

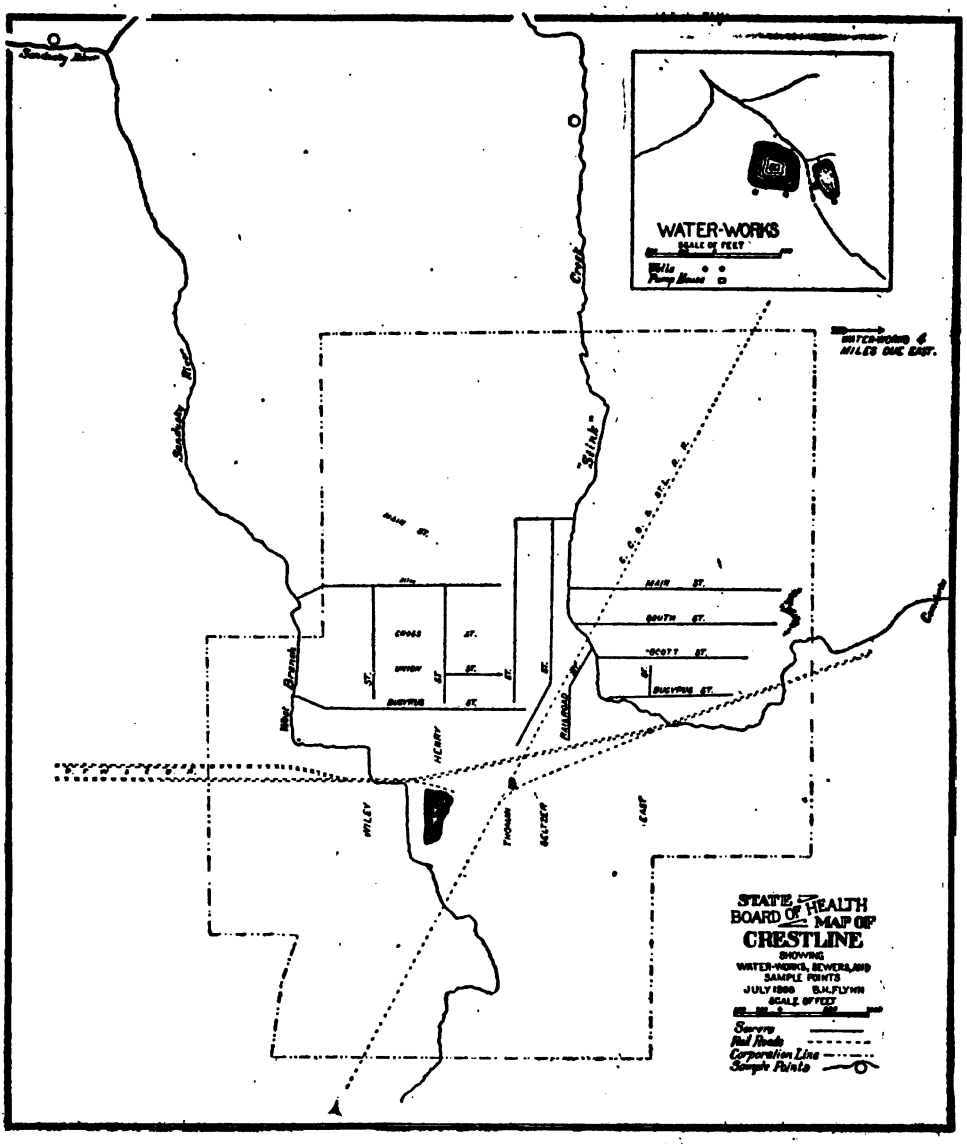
Napoleon, on the Maumee river, discharges its sewage into that stream. So far no nuisance has been caused thereby. The uppermost sewer, however, discharges into the river not far below where water is taken from the river for water works purposes. A dam in the river gives almost slack water at this point, and during up-river winds the sewage is driven above the water works intake. Napoleon's water supply is further menaced by the sewage of Defiance, a city of 9,505 inhabitants, seventeen miles above.

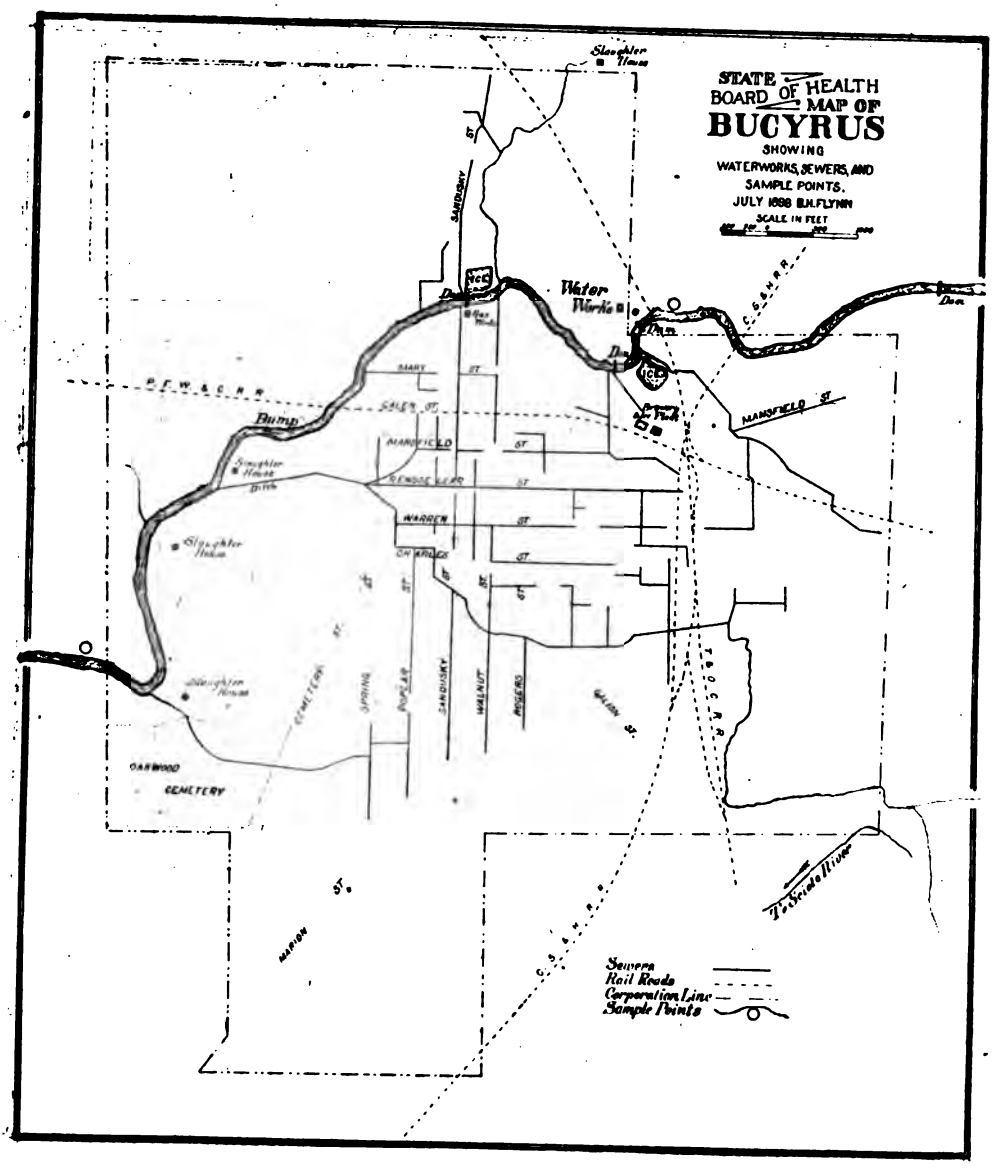
Toledo, a city of about 120,000 inhabitants, at the mouth of the Maumee river, discharges its sewage into the river and into Swan creek. Complaint has already been made of the pollution of this creek. The city obtains its water supply from the river. The Children's Home, and several club houses and summer resorts, not more than five or six miles above the water works intake, discharge their sewage into the river, endangering, to some degree, the city's water supply. A few miles above these sources of contamination are the growing towns of Maumee and Perrysburg. Both places are discussing the question of sewerage, with no other practical outlet except the Maumee river.

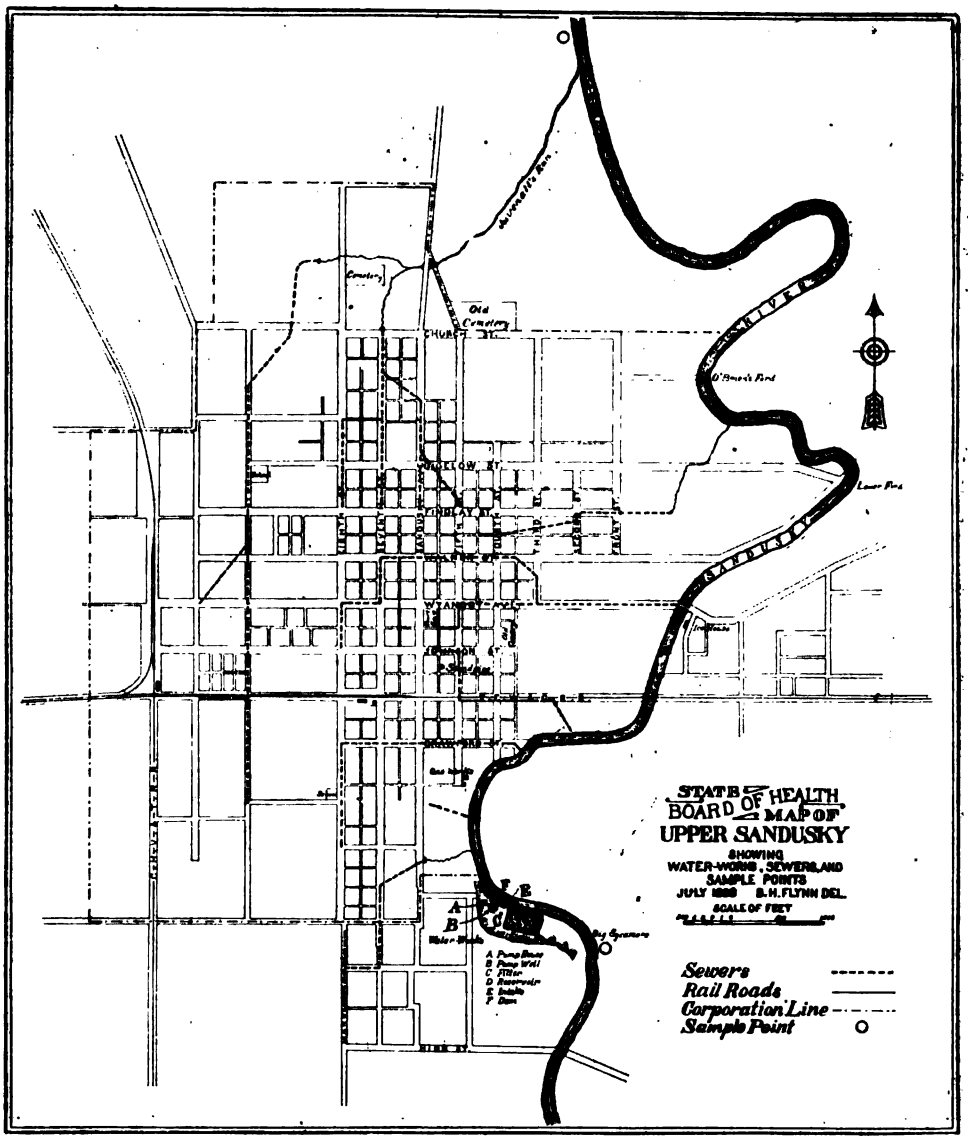
To briefly sum up the results of the year's investigation, they show conclusively that both the Sandusky and Maumee rivers are already polluted at many places beyond the limit of safety, and that in no place do their waters afford a perfectly safe domestic supply.

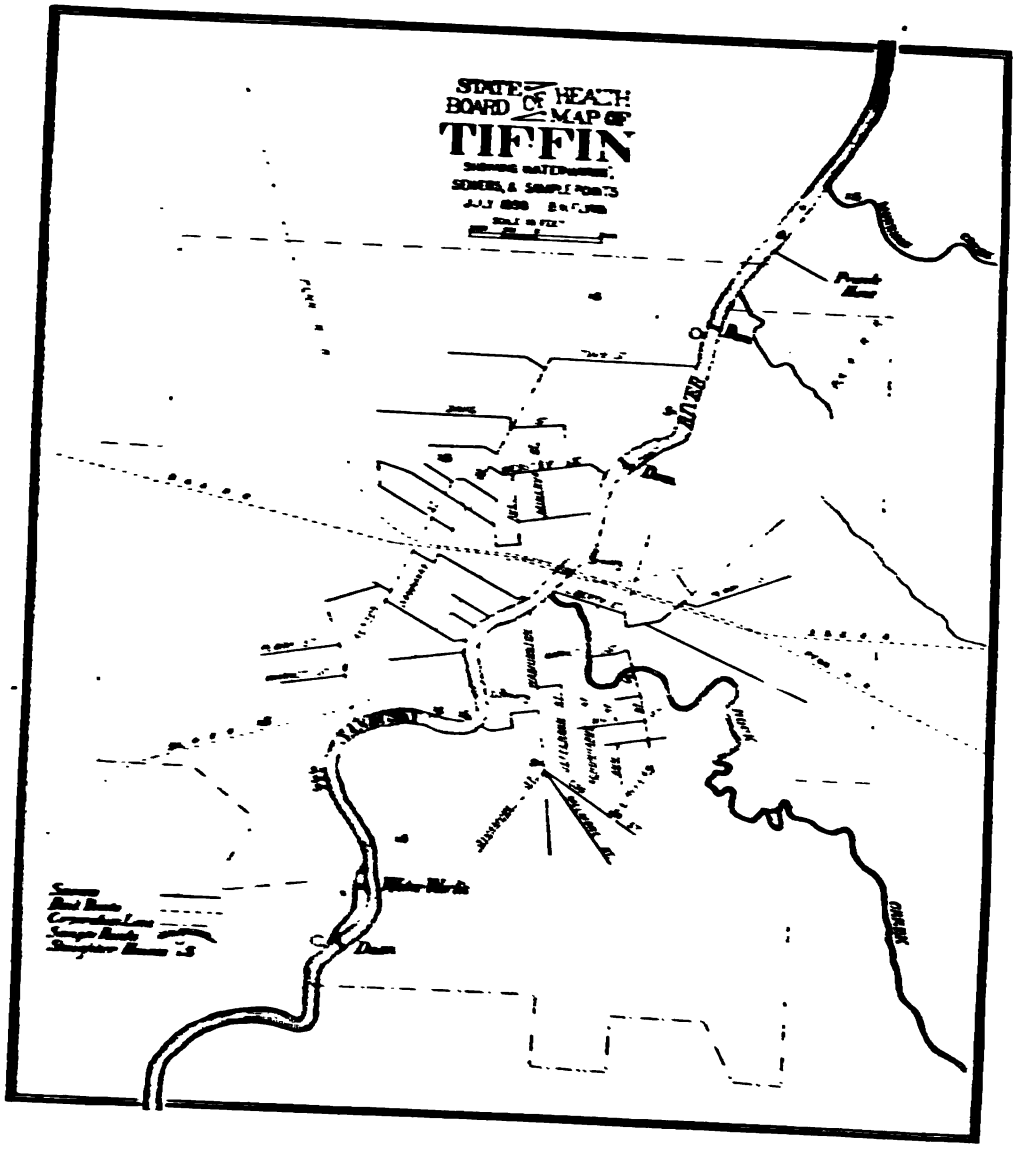
Following are the reports of the chemist, bacteriologist and engineer:

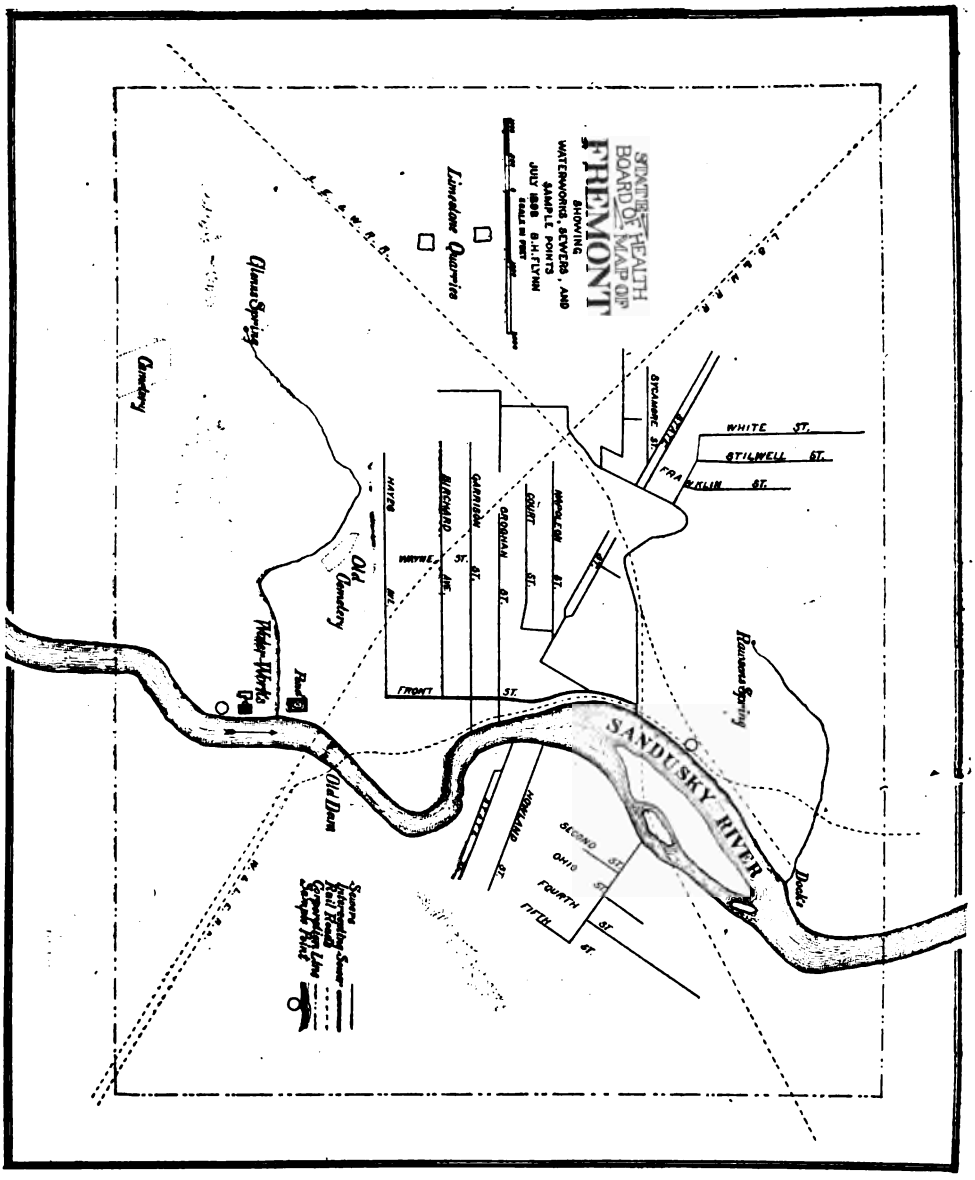


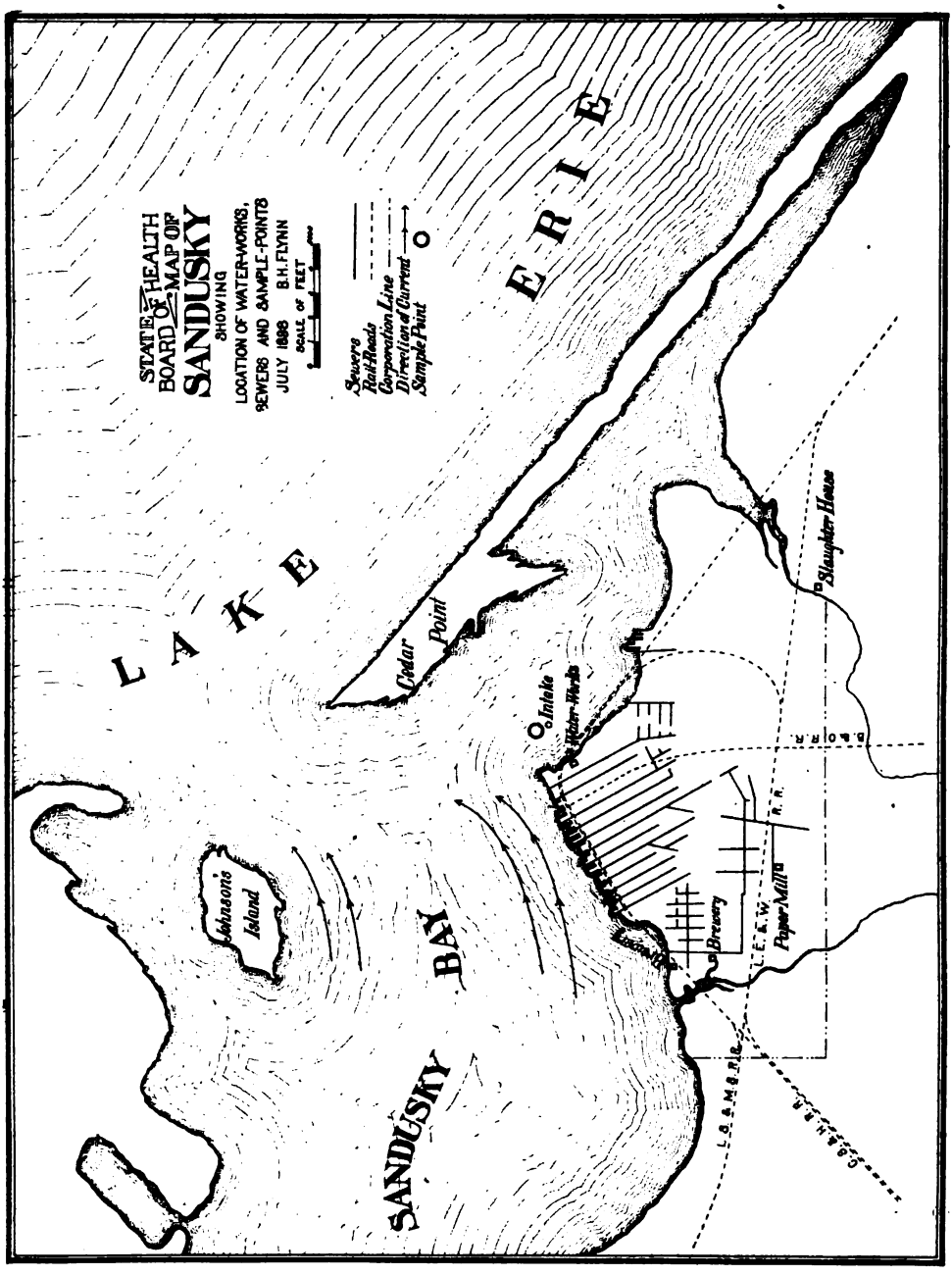

WATER-WORKS
SCALE OF FEET
Wells
Pump Houses
Sandusky River
Coon
Sulphur
Broken
Main St.
Main St.
South St.
Wiley St.
Sulphur St.
Railroad
Henry
Wiley
Thomas
Belter
East
STATE BOARD OF HEALTH MAP OF CRESTLINE
SHOWING
WATER-WORKS, SEWERS, AND
SAMPLE POINTS
JULY 1899 BAUFLYNN
SCALE OF FEET
Sewers
Rail Roads
Corporation Line
Sample Points

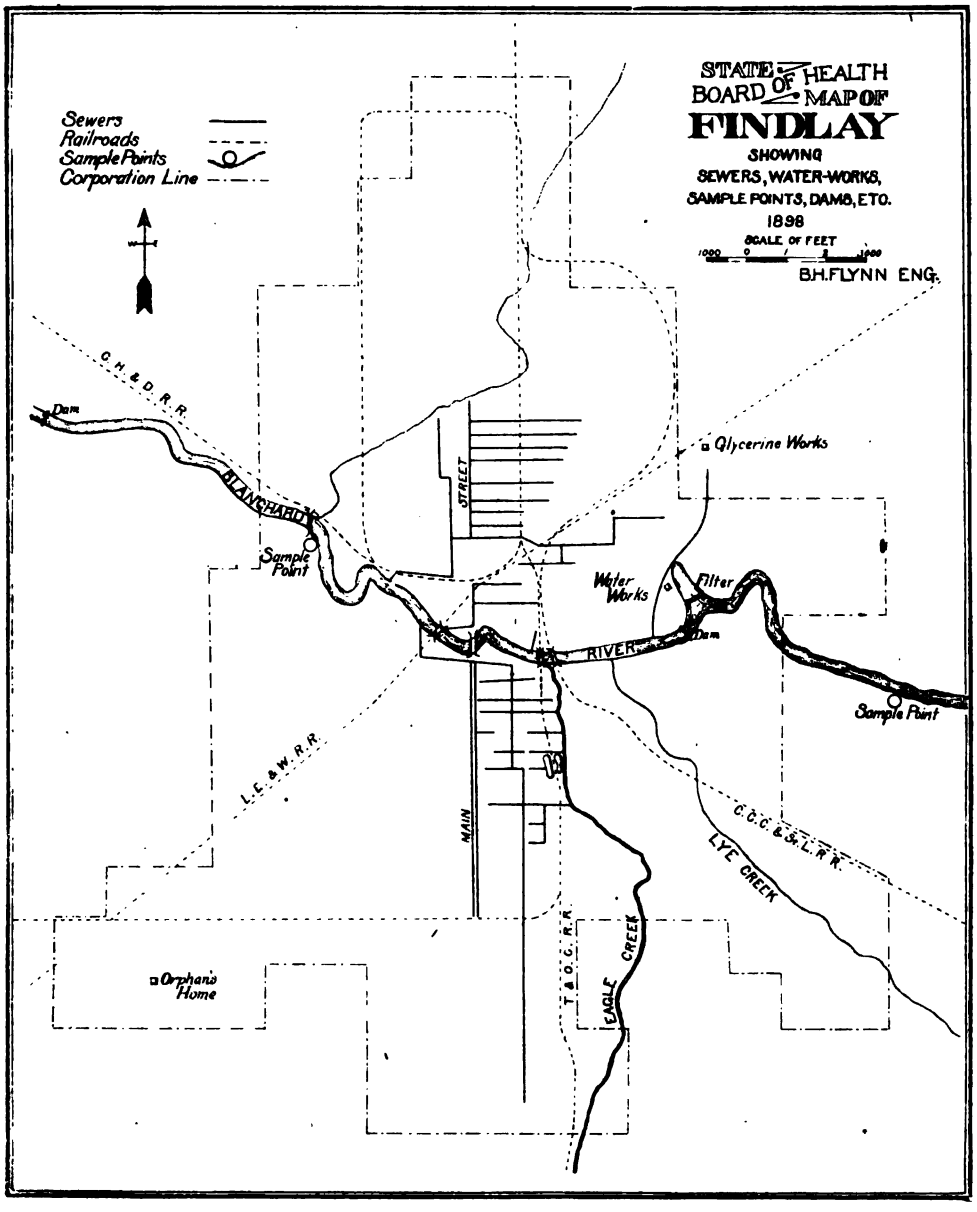

STATE BOARD OF HEALTH
MAP OF
BUCYRUS
SHOWING
WATERWORKS, SEWERS, AND
SAMPLE POINTS.
JULY 1898 B.H.FLYNN
SCALE IN FEET
Slaughter House
Water Works
Pump
Ice
Ice
Dam
Dam
C.S.&M.R.R.
P.F.W.&C.R.R.
SANDUSKY ST.
MARY ST.
SAUER ST.
MANSFIELD ST.
SYCAMORE ST.
WARREN ST.
CHURCH ST.
SPRING ST.
POPLAR ST.
WALNUT ST.
ROGERS ST.
WILSON ST.
CEMETERY ST.
OAKWOOD CEMETERY
MARION ST.
Tee Scioto River
Sewers
Rail Roads
Corporation Line
Sample Points

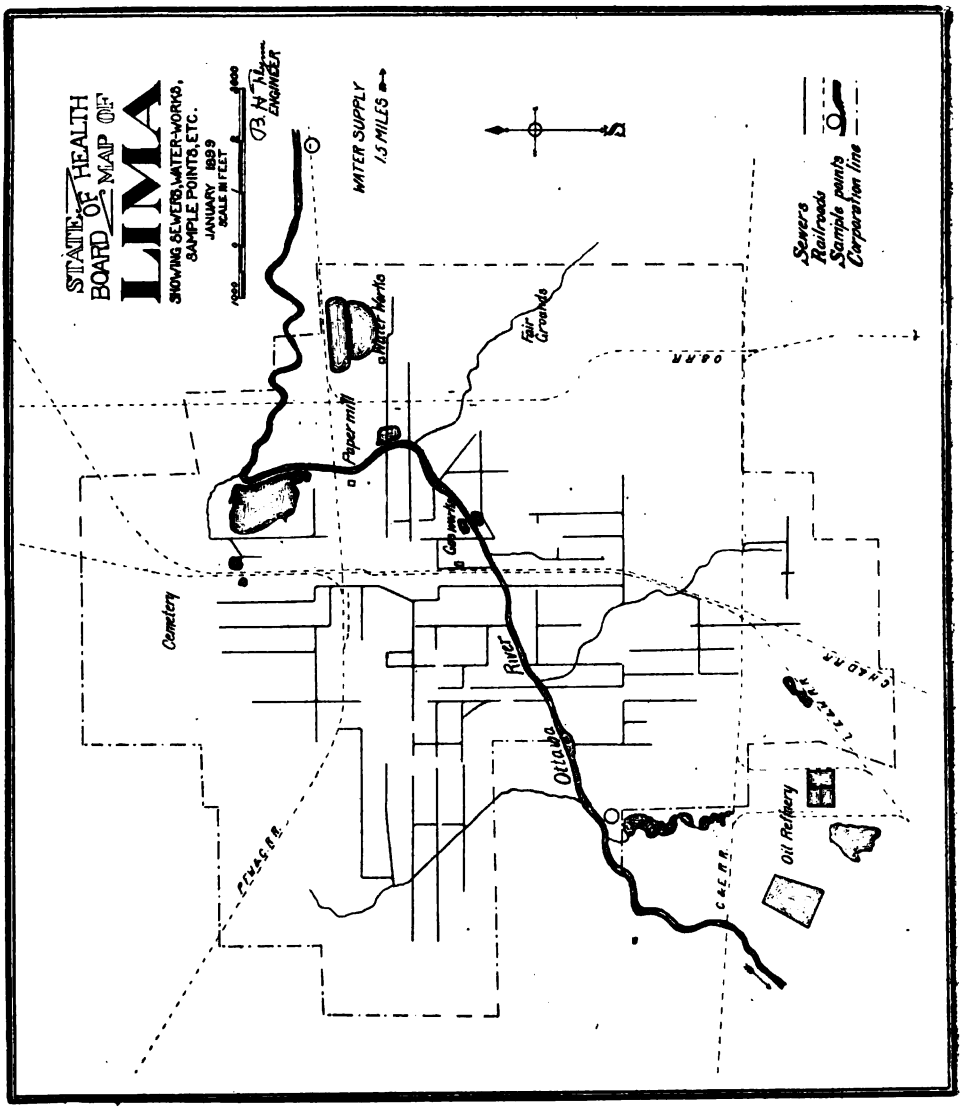

STATE BOARD OF HEALTH
MAP OF
UPPER SANDUSKY
SHOWING
WATER-WORKS, SEWERS, AND
SAMPLE POINTS
JULY 1898 B. H. FLYNN DEL.
SCALE OF FEET
Sewers
Rail Roads
Corporation Line
Sample Point
A Pump House
B Pump Well
C Filter
D Reservoir
E Intake
F Intake
Old Cemetery
CHURCH ST.
WILLOW ST.
CINDLAY ST.
SANDUSKY
Lower Rapids
O'Brien's Rapid
Water Works
Big Cemetery

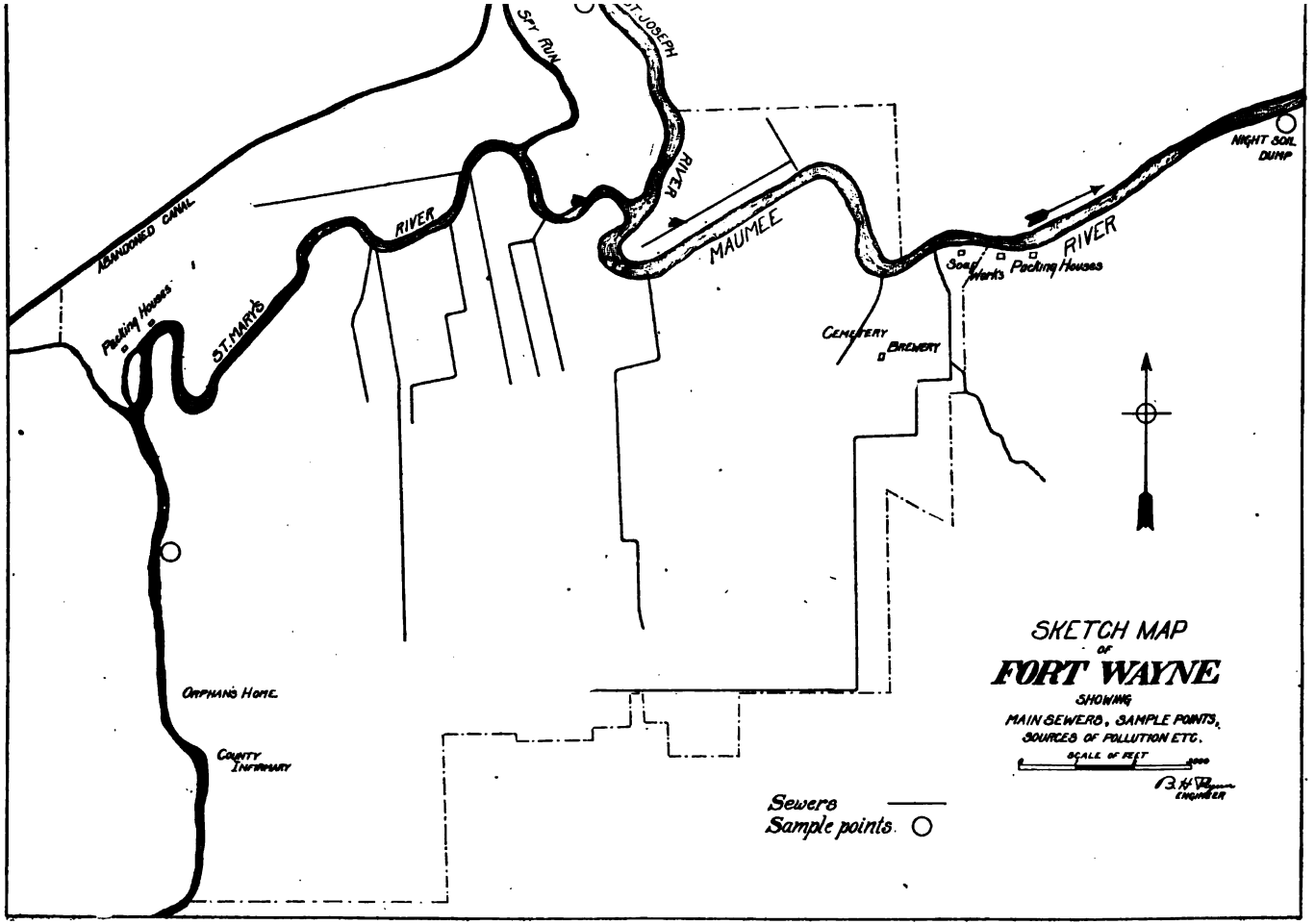

STATE BOARD OF HEALTH
MAP OF
TIFFIN
RIVER

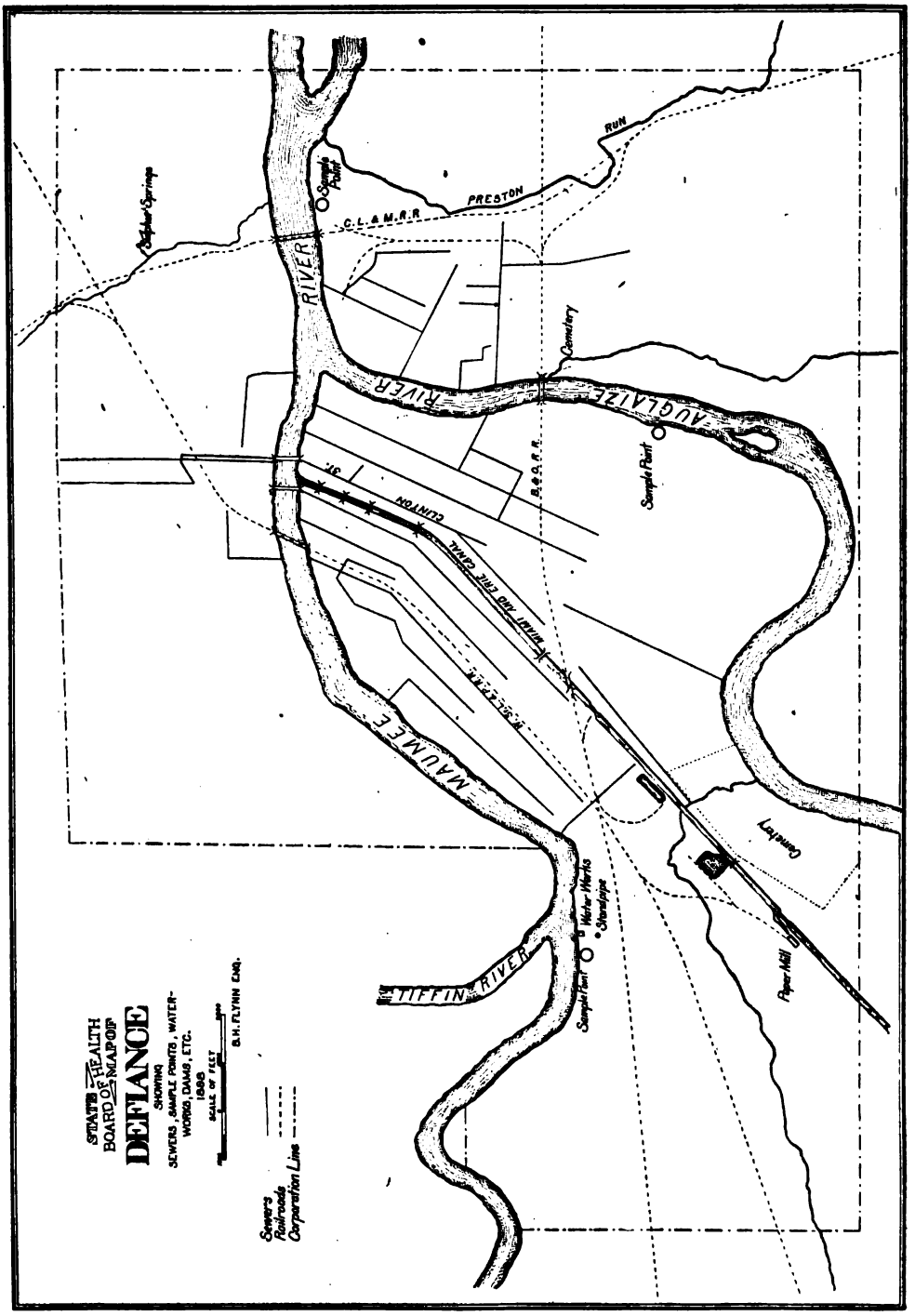

STATE BOARD OF HEALTH MAP OF
FREMONT
SHOWING
WATERWORKS, SEWERS, AND
SAMPLE POINTS
JULY 1888 B.H.FLYNN
SCALE IN FEET
Limestone Quarries
Limestone Spring
Cemetery
Old Cemetery
Water-Works
Old Dam
Rapids
Rocky Spring
SANDUSKY RIVER
WHITE ST.
STILWELL ST.
FRANKLIN ST.
SYCAMORE ST.
HAYES AVE.
WAYNE AVE.
BIRCHARD ST.
GARRISON ST.
GEORGIAN COURT
MONROE ST.
FRONT ST.
HORKANS ST.
SECOND ST.
OHIO ST.
FOURTH ST.
FIFTH ST.
Sewers
Pipe Drains
Sewer Pipe Line
Scale 1000 Feet

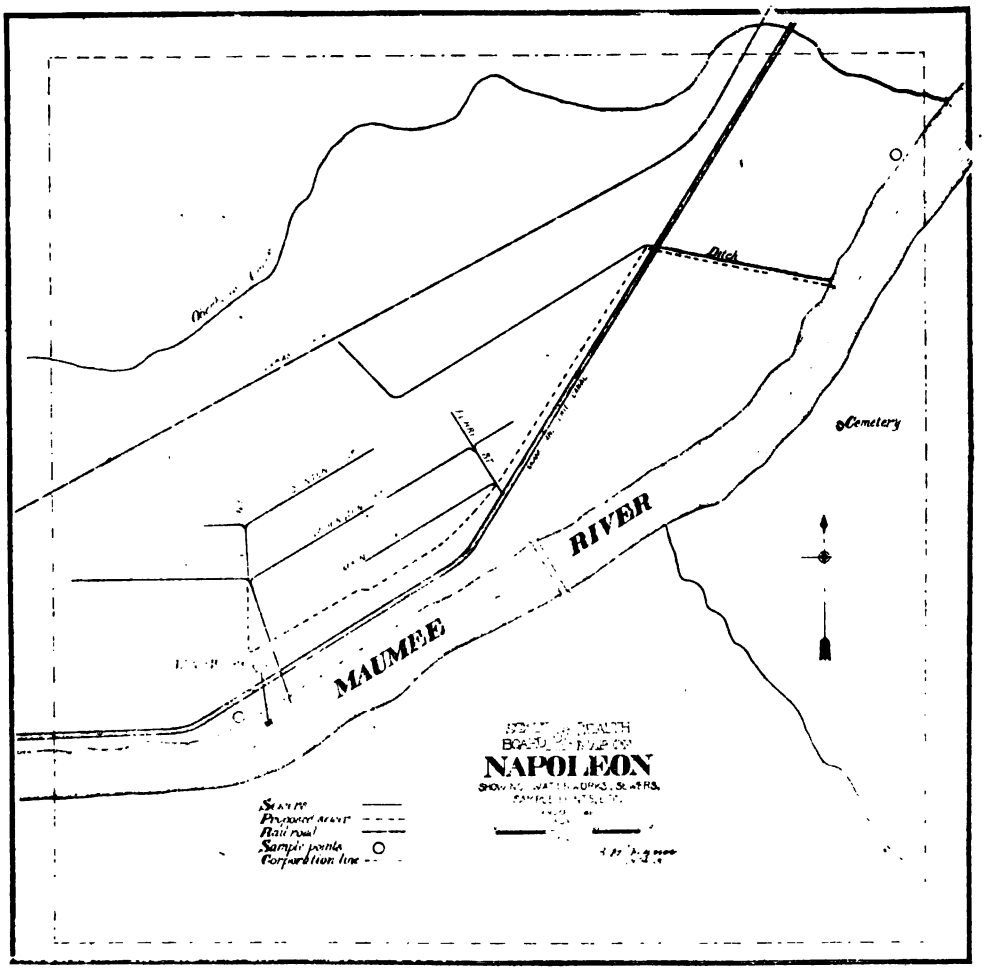

STATE OF OHIO HEALTH BOARD MAP OF
SANDUSKY
SHOWING
LOCATION OF WATER-WORKS, SEWERS AND SAMPLE-POINTS
JULY 1898 B.H. FLYNN
SCALE OF FEET
Sewers
Railroads
Corporation Line
Direction of Current
Sample Point
LAKE ERIE
Cedar Point
Intake
Water-Works
Slaughter House
Johnson's Island
SANDUSKY BAY
Brewery
L.E.&W.R.R.
Paper Mills
L.S.&M.S.R.R.
C.S.&H.R.R.

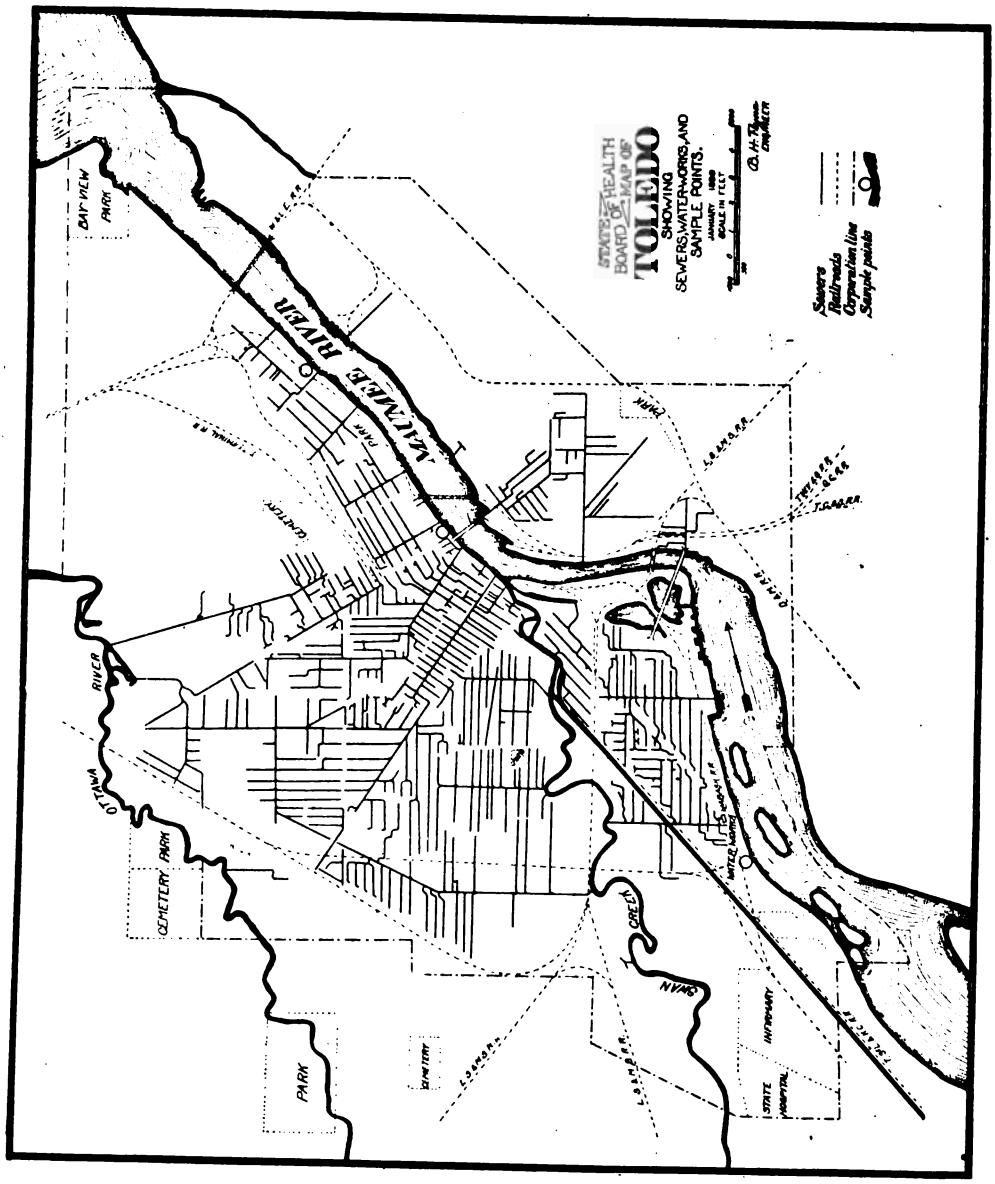

STATE BOARD OF HEALTH
MAP OF
FINDLAY
SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, DAMS, ETC.
1898
SCALE OF FEET
1000 0 1 2 3000
B.H.FLYNN ENG.
Sewers
Railroads
Sample Points
Corporation Line
C. H. & D. R. R.
Dam
BLANCHARD
Sample Point
O STREET
Glycerine Works
Water Works
Filter
Dam
RIVER
Sample Point
L. E. & W. R. R.
MAIN
C. C. C. & St. L. R. R.
LYE CREEK
T. & O. C. R. R.
EAGLE CREEK
Orphan's Home


STATE HEALTH BOARD OF MAP OF
LIMA
SHOWING SEWERS, WATER-WORKS, SAMPLE POINTS, ETC.
JANUARY 1899
SCALE IN FEET
B. H. Jr. ENGINEER
WATER SUPPLY 1.5 MILES
Sewers
Railroads
Sample points
Corporation line
Paper mill
Fair Grounds
Cemetery
River
Ottawa
Oil Refinery
C. H. & D. R. R.
C. A. & C. R. R.
C. L. & N. R. R.


ST. JOSEPH
ST. RUN
RIVER
ABANDONED CANAL
RIVER
MAUMEE
NIGHT SOIL DUMP
RIVER
Soap Works
Packing Houses
Packing Houses
ST. MARYS
CEMETERY
BREWERY
ORPHANS HOME
COUNTY INFIRMARY
SKETCH MAP
OF
FORT WAYNE
SHOWING
MAIN SEWERS, SAMPLE POINTS,
SOURCES OF POLLUTION ETC.
SCALE OF FEET
ENGINEER
Sewers
Sample points


STATE HEALTH BOARD OF MAP OF
DEFIANCE
SHOWING
SEWERS, SAMPLE POINTS, WATER-WORKS, DAMS, ETC.
1908
SCALE OF FEET
B.H. FLYNN ENG.
Sewers
Railroads
Corporation Line
TIFFIN RIVER
MAUMEE
RIVER
AUGLAIZE
RIVER
Sulphur Springs
Sample Point
C.L.A.M.R.R.
PRESTON
RUN
Cemetery
Sample Point
B.&O.R.R.
DAM
CANYON
MIAMI AND ERIE CANAL
N.Y.C.R.R.
Sample Point
Water Works
Standpipe
Cemetery
Paper Mill


Ditch
Cemetery
RIVER
MAUMEE
NAPOLEON
Railroad
Corporation line


STATE BOARD OF HEALTH
MAP OF
TOLEDO
SHOWING
SEWERS, WATER-WORKS, AND
SAMPLE POINTS.
Sewers
Railroads
Corporation line
Sample points
MAUMEE RIVER
OTTAWA RIVER
BAY VIEW PARK
CEMETERY PARK
PARK
STATE HOSPITAL
WATER WORKS
CREEK
LAKE ERIE

REPORT ON THE CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF THE WATERS OF THE SANDUSKY AND MAUMEE RIVERS.

By E. G. Horton, B. S.,

Chemist and Bacteriologist Ohio State Board of Health.

The systematic examination of the river waters of Ohio commenced in 1897 will extend over a period of several years, and, accordingly, it is desirable that the work of each year be presented in such form as to make the results readily comparable with those of the preceding years. To this end we have followed in the main the very satisfactory methods employed last year by Prof. N. W. Lord and Dr. A. M. Bleile in their work upon the Scioto, Olentangy and Mahoning rivers. There is however, one marked departure from the preceding work, and one which must constantly be borne in mind to avoid confusion. We refer to the method of expressing the results. All numerical results, except for color, dissolved oxygen and bacteria, are expressed in *parts per million*, and not in parts per one hundred thousand, as in the preceding work. This change was made at this time, rather than later, because the growing tendency among scientific workers is so strongly in favor of the more convenient milligrams per litre by weight (parts per million) that we believe the one method of expressing results will soon prevail. Parts per hundred thousand should be multiplied by ten before comparison is made with parts per million.

All of the examinations and collections were made by the writer The temperature reading, the test for dissolved oxygen, and the pouring of plates for determining the number of bacteria, were made at the river bank at the time of sampling. The remaining determinations were made in the Laboratory of the Ohio State Board of Health from a bottle of water taken at the time of sampling, then securely locked in a wooden box prepared for the purpose, and shipped by express to the laboratory. These bottles hold about one gallon each and are supplied with ground glass stoppers. As soon as the samples reached the laboratory the bottles were removed from the wooden boxes and placed in a refrigerator kept well supplied with ice. Some criticism has been made because of delay which would result from collecting and analyzing of the samples by the

same person. While it would have been desirable to have had two workers on the laboratory staff, yet the funds at the disposal of the Board would not permit such a course. Moreover, the delay is not so great as it would seem at first thought. Under the most favorable circumstances samples collected in the forenoon would reach the laboratory too late to be examined that day. On the other hand many of the samples would not reach the laboratory even the next day after collection. By reference to last year's report (pages 54 59) it will be seen that about one-fourth of the samples did not reach the analyst until the second day after their collection. In the present work the writer was able to complete the trip over either watershed and reach Columbus again on the third evening. It was actually found that with the same person doing both collecting and analyzing that fifty (50) per cent. of the samples received no delay whatever in beginning of the examination, and that the analysis of no sample was delayed beyond forty-eight hours from what it would have been with an additional person to do the collecting. Furthermore, the research work (not yet published) of Mr. F. O. Clements, Fellow at the Ohio State University, 1898 99, shows that the most rapid change is a great increase in nitrates. In the majority of the samples in the present report the nitrates were not excessive, and when they were it was true of all samples regardless of any delay in analysis. We do not claim that some changes did not occur, but we do believe that they were not of such moment as to materially affect the comparability of results.

The first steps in the analysis were to determine the condition of the organic matter present, then the physical characters, chlorine, total solids, alkalinity and incrusting constituents. Before beginning the analysis of a sample, the neck of the bottle was held under the tap to wash away any dust and then rinsed with distilled water.

As soon as the examination was completed the bottle was thoroughly cleansed and rinsed, and in addition, before again sending out the bottles, they were rinsed with ammonia free water, and this water was Nesslerized to see if any ammonia was present.

The plan of the work consisted in the chemical and bacteriological examination of samples taken at regular places in the Sandusky and Maumee rivers each month from July to November inclusive. The regular places for sampling were chosen above and below the known sources of pollution. When any city used the river water for a public supply the above-town sample was taken at or near the water works. The series of examinations enables us to arrive more correctly at the sanitary value of the water supplied in this way to the consumers.

A comparison of the results below any particular pollution with the results obtained above that disturbance shows the extent of the impurity

added. On the other hand; a comparison of the results below a pollution with the results at the next station down the river shows the amount of purification which has taken place. The results yield information upon urban and rural sewage pollution, specific pollutions of various kinds, and purification questions.

METHODS.

Color. The color was determined by Hazen's platinum cobalt method. *American Chemical Journal, XIV, p.* 300. A solution with a color 5 is made by dissolving 1.246 grams of bichloride of platinum and potassium in water, adding 1 gram of cobalt chloride and 100 c. c. of concentrated hydrochloric acid, then diluting to 1 litre. From this solution weaker standards are prepared and kept in bottles for comparison with the water to be examined. A standard of .1 color is obtained by diluting the strong solution 1 to 50, .2 by 2 to 50, .3 by 3 to 50, etc. Turbid waters were filtered before being tested for color. The comparison of the water with the standards was made in tall Nessler tubes by looking through the tubes lengthwise against a pure white surface.

The *turbidity* and *sediment* were determined by inspection of the water in the sample bottles after standing over night. The turbidities were expressed as follows: None, very slight, slight, distinct, decided, and are indicative of the suspended matter present, chiefly in the form of soil (clay) and low forms of animal and vegetable life. Frequently one of the most, if not the most objectionable feature of a water, from the consumer's standpoint, is its appearance or turbidity.

The river waters of Ohio are quite turbid, if the streams under discussion in this report are representative streams. With the surface waters in some sections so badly polluted as to be at least suspicious in character, an increased population will necessitate purification plants if the rivers continue to be the source of public supply for many of our towns and cities. The suspended clay in a water is extremely difficult of removal by filtration, and yet is such an important factor in turbidities that it makes it advisable to have more expressive terms for turbidities than adjectives.

The sediments were mostly composed of depositions of the larger soil particles, higher plant forms, and the remains of decaying organic matter, either of vegetable or animal nature. Sediments were spoken of as none, very slight, slight, considerable and much. In the tables the expressions for turbidities and sediments are abbreviated as follows: Very slight, v. s.; slight, s.; distinct, dis.; decided, dec.; considerable, c.; and much, m.

The *odor* was determined at room temperature by shaking a partially filled sample bottle, which had stood over night, and applying the nose

to the mouth of the bottle at the moment the stopper was withdrawn. In a few cases the odor was also taken from some of the water heated almost to boiling in a clean flask.

The amount of *oxygen required* was found by the well known Kübel process, using 100 c. c. of water and boiling gently for ten minutes. The tests were made in 200 c. c. Erlenmeyer flasks previously freed from organic matter. To the water was added 5 c. c. of 25 per cent. H_2SO_4 (free from organic matter) and a known amount of the permanganate solution (8 to 10 c. c.). More permanganate was added if the red color began to fade during boiling. At the end of the ten minutes, exactly 10 c. c. of oxalic acid solution was added and the titration completed with the permanganate. The amount of permanganate used, less the equivalent of the 10 c. c. of oxalic acid, gave the amount of oxygen required. The strengths of the permanganate solution and the oxalic acid were as 1:1, but a titration was made each day they were used to determine exactly their relative values. Ten c. c. of the dilute oxalic solution was equivalent to 1 mg. of oxygen. The samples were well shaken before the portion was taken for examination.

The *nitrogen* in the form of *free and albuminoid ammonia* was determined by the Wanklyn process, as modified by Drown, Hazen and Clark. The method is that used by the Massachusetts State Board of Health, report 1890, and by Prof. N. W. Lord, in the work of 1897, for the Ohio Board. In brief, it consists in distilling from flasks or retorts containing 500 c. c. of the sample three distillates of 50 c. c. each for the free ammonia, then after the addition of 40 c. c. of alkaline permanganate, five more distillates are obtained for the albuminoid ammonia. The time of each distillate was kept as nearly as possible at fifteen minutes. The condensing tubes were kept cold by running water. The flasks, retorts, and condensing tubes were tested in place each time before using, to show they were free from ammonia. All Nessler tubes were also tested before using. The only acid samples were the August ones from Findlay, and these were the only ones made alkaline by the addition of sodium carbonate. Clean pumice stone, in small granules, previously heated for two hours, prevented "bumping." The permanganate was tested in blank when made up, then heated to boiling for some minutes before using. It was prepared from the customary formula, as was the Nessler's re-agent. Each preparation of the stock solutions was tested with the preceding, and no appreciable variation found.

Standards were prepared for each day's reading by adding known quantities of an ammonium chloride solution to 50 c. c. tubes of ammonia free water. The standards and distillates, protected from contamination, were allowed to come to a uniform temperature by

standing, then Nesslerized and the readings taken after fifteen minutes, when the colors had become constant. The Nessler tubes were 300 mm. long, with an interior diameter of 18 mm. Distillates rich in ammonia were diluted in aliquot parts. When a water was known to be impure less than 500 c. c. was taken and diluted to that amount with ammonia free water. Before taking the portion desired for the examination the water in the sample bottle was well shaken.

The determination of the *nitrogen as nitrites* was made by the Griess-Warrington method as described in Report of the Massachusetts State Board of Health for 1890, (part 2, p. 715). In turbid waters a portion was first shaken up with hydrate of alumina, and quickly filtered through a paper filter which had been washed free of nitrous acid. In each case 50 c. c. of the water in question was taken and the test made in tall Nessler tubes by comparing the depth of color with that in standards made up in similar tubes from nitrite free water and known quantities of sodium nitrite. The readings were made thirty minutes after the addition of the solutions, the tubes meanwhile having been protected so as to prevent absorption of nitrites from the air or dust.

The *nitrogen as nitrates* was determined, with slight modifications, by the indigo process as given in Sutton's Volumetric Analysis, 7th edition, p. 469. The phenoldisulphonic acid method was not employed as the determination of free and albuminoid ammonia is carried on in both rooms of the laboratory, thus preventing there the use of ammonia. Aluminum foil for the aluminum reduction process had been ordered but was so long delayed in reaching us that the first determinations were of necessity made by the indigo process, and no change was subsequently made.

Chlorine. The amount of chlorine was found by the well known process of titration with silver nitrate, using potassium chromate as an indicator. See Hazen, *American Chemical Journal, Vol. XI* p. 409. Blank determinations furnished the data for correction, for volume and quantity of silver chloride. These tests were made by artificial light. Turbid waters were clarified by shaking with hydrate of alumina. The waters were so very high in chlorine that the addition of sodium chloride solution was not thought of, and some of the samples were diluted. In each case 100 c. c. was used, and the end reaction found by comparison with a prepared flask containing the same volume.

Alkalinity. This was determined by the Hehner method of titration with one-fiftieth normal sulphuric acid using lacmoid as an indicator. Fifty c. c. of the water were heated almost to boiling for the titration and the results were expressed as calcium carbonate in milligrams per litre.

The Hehner method was likewise used to determine the *incrustin*

constituents. See *Analyst*, (*Vol. VIII, p.* 77.) As in the work of last year the lack of a sufficient number of platinum dishes necessitated the use of porcelain. Blank determinations were run each time and corresponding connections made. To 50 c. c. of the water under examination was added a measured amount of a fiftieth normal sodium carbonate solution, and the mixture evaporated to dryness. The soluble salts were carefully washed through a small filter with freshly boiled distilled water, the filtrate titrated with fiftieth normal sulphuric acid, and the difference between this result and the amount from the sodium carbonate in the blank taken as representing the sulphates and chlorides of calcium and magnesium expressed as calcium carbonate.

Like Prof. Lord we found the soap test very unsatisfactory for the hard waters found in Ohio streams, but the Hehner test yielded excellent results.

Total solids and loss on ignition. The sample was well shaken, 100 c. c. taken, and evaporation to dryness and constant weight effected. The ignition was carried as uniformly as possible to a faint visible redness until the carbonaceous matter was gone.

The test for *dissolved oxygen* was of necessity made at the river bank, with strict precautions observed in taking the sample so as to guard against error due to increase of oxygen by virtue of bringing the water in contact with air through careless manipulation. Winkler's method was employed as follows: A narrow neck bottle of known capacity (165.5 c. c.) with a close fitting ground glass stopper, was immersed in the stream and allowed to fill, then by means of a rubber tube with one end extending to the bottom of the bottle and having at the other end a rubber bulb used as a suction pump, a quantity of water, equal to several times the capacity of the bottle, was drawn through the bottle which was kept immersed all the time. Finally the tube was withdrawn, the stopper inserted, and the bottle lifted from the stream. With fine pointed pipettes $\frac{1}{2}$ c. c. of a clear saturated solution of manganous sulphate and 1 c. c. of a potassic iodide solution (100 grams potassic iodide and 360 grams caustic soda in one litre of water) were successively introduced beneath the surface, and the stopper at once replaced, care being taken to include no bubbles of air. The bottle was turned so as to thoroughly mix the contents, and then allowed to stand until the precipitate settled. Five c. c. of the 25 per cent. solution of sulphuric acid was similarly introduced and the contents again well mixed, when there was set free iodine in proportion to the free oxygen previously in the water. The amount of iodine was found by titration against a hundreth normal sodium thiosulphate, using starch as an indicator. The titration was made in a porcelain casserole. The amount of dissolved oxygen was computed

from the thiosulphate used, and was expressed in percentage of the amount held by distilled water at that temperature when saturated by shaking with air. We used the table for saturations given by Prof. Lord's report last year and which is repeated below.

As in preceding work on streams in this State there were found at times, amounts of dissolved oxygen greater than those given in the tables for saturation. We believe these high results are reliable, and that their occurrence is consistent with the attending conditions. These supersaturations occurred chiefly in July and August, and were doubtless due to the oxygen given off by growing plants. In Annuaire de L'Observatoire Municipal de Montsouris pour l'an, 1890, we find work which bears out the supersaturations we have more recently found. That report, p. 250, in speaking of dissolved oxygen in waters, says, "Cet oxygène provient de l'air dessous dans plus loin, du produit de la nutrition des algues qui vivent dans cette eau." On pages 260 and 261 we find a table showing the decrease of oxygen in water due to microbic life, and the following table showing the increase of free oxygen resulting from the presence of growing algae:

Eau de Vanne (contained)	11.1	milligrammes.
" " apres 9 jours	20.2	"
" " " 60 "	39 7	"

The temperature was not given, but the amount of dissolved oxygen had increased after nine days to supersaturation if computed in percentage of saturation from the usual tables, and had increased still more at 60 days. "Ces résultats différentes proviennent de la plus ou moins grande quantité dans les eaux de matières organisées vivantes, les unes chlorophyllées, les autres non-chlorophyllees, des algues et des bacteries par exemple." That is they found a water containing chlorophyll plants as algae increased in its amount of dissolved oxygen, while water rich in bacterial life lost free oxygen on standing.

Saturation tables are prepared from results obtained by shaking water with air, which contains only some 20 per cent. of oxygen. The gas given off by algae is nearly pure oxygen, and consequently a water would take up about five times as much oxygen from it as from the same volume of air, temperature and pressure remaining the same. It would have been extremely desirable could the waters yielding the higher results have been examined biologically, but the demands of the routine work permitted no time for even a slight investigation as to the nature of the plants occurring in those waters.

QUANTITIES OF DISSOLVED OXYGEN IN PARTS PER MILLION, BY WEIGHT, IN WATER SATURATED WITH AIR AT THE TEMPERATURE GIVEN.

(Milligrammes per Litre.)

Temperature C.	Oxygen.	Temperature C.	Oxygen.
0	14.70	16	9 94
1	14 27	17	9 74
2	13 87	18	9.55
3	13 50	19	9.37
4	13.15	20	9 19
5	12.82	21	8.97
6	12 48	22	8 84
7	12 17	23	8.67
8	11.87	24	8 51
9	11.58	25	8 35
10	11.31	26	8.19
11	11 06	27	8.03
12	10 82	28	7.90
13	10.59	29	7.74
14	10.36	30	7.60
15	10.14		

BACTERIOLOGICAL METHODS.

It is a source of regret that we were unable to include in this work a systematic search for intestinal bacteria in each sample. It was only by earnest work and long hours that the amount of work accomplished in the laboratory was attained, and therefore the qualitative examination for members of the colon group of bacilli was of necessity deferred until more assistance could be provided. We hope to be able to include in future reports information concerning the presence or absence of intestinal bacteria. Still, as has been said, much can be gained from a knowledge of merely the number of germs present, and this, when considered with the chemical findings, is of great assistance in determining the sanitary value of a water. Sudden or great fluctuations in the number of bacteria do not come without cause.

The number of bacteria was determined by the usual quantitative method in vogue, using agar and petri plates. We used the usual nutrient agar, containing 12 grams of agar to the litre.

The reaction of the culture medium in water analysis is an item of great importance, as frequently marked variations are obtained in the number of bacteria from the same sample when media of different reactions are employed. In all our work the reaction was 1.5 per cent. acid as has been the practice of the writer for the past few years. This reaction means that it would require 15 c. c of a normal alkali solution to be

added to one litre of the medium to bring it to the phenolphthalein neutral point. This medium then is acid to phenolphthalein and alkaline to litmus. Agar was chosen in preference to gelatine, because the latter would not stand the heat of our summers, and it was not practicable to maintain the gelatine at a low temperature in the collector's case while traveling.

The growths developed at ordinary temperatures, and counts were made at the laboratory at the end of three days in hot weather and four days in the fall. This was possible, as the length of the trips always permitted the bacteriologist to be in the laboratory by the time the first plates were 72 hours old. To avoid bacterial changes in transportation all plates were poured at the river bank, and no trouble was found in accomplishing this satisfactorily. The agar was liquefied in the flame of an alcohol lamp, and the tubes placed in a water bath at 42° C. for a few minutes. Usually .5 and 1 c. c. were the amounts of water used for the plates, but in waters known to be badly polluted, dilutions with sterile distilled water were made. Two plates were poured at each station and the mean taken as the final result, the figures showing the number of bacteria in 1 c. c. of the original water.

The pipettes, petri plates and test tubes for taking the samples were sterilized at the laboratory before starting on the trip, and no tube or pipette was used again until cleaned and resterilized.

The plates were placed in pairs in pasteboard boxes made for the purpose, while the pipettes were sterilized and carried singly in small brass tubes plugged with cotton at either end.

It is essential in forming an opinion of a river water from the findings of the chemical and bacteriological analyses to bear in mind the effects produced in streams by the addition of rain water. As rains occur at irregular intervals and with no uniformity of fall, the time and extent of the precipitation must be noticed. In addition to the influence of the rain water itself there must be considered a usually more important factor resulting therefrom, viz , the nature of the substances brought into the river by the consequent surface washings and the effect thus produced upon the water.

To this end the following rainfall table has been compiled from the monthly reports of the United States Weather Bureau. Thanks are due Mr. J. Warren Smith, Director of the Ohio Section, for courtesies extended and for the interest shown in making the work of the Weather Bureau of assistance to us by locating observing stations at desirable points on the watersheds.

The table includes the date and the amount of rainfall (when there was a precipitation of one-tenth inch or more) for all observing stations of the Bureau located upon the areas drained by the Sandusky or Maumee rivers and their tributaries. The sum of the amounts given may not equal the total for the month, as precipitations of less than one-tenth of an inch have been omitted.

RAINFALL TABLE.

Days on Which One-tenth Inch or More Rainfall Occurred—Sandusky River Basin.

Station.	July.	Rain.	August.	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
Bucyrus	15	.10	3	.80	22	.19	.....	.....	.....	.....
"	16	.20	4	.30	23	.96	.....	.....	.....	.....
"	18	1.00	8	.30	24	.21	.....	.....	.....	.....
"	19	.80	9	.30	.....	.....	.....	.....	.....	.....
"	21	.50	17	.30	.....	.....	.....	.....	.....	.....
"	25	.10	19	.50	.....	.....	.....	.....	.....	.....
"	28	.10	25	2.00	.....	.....	.....	.....	.....	.....
"	29	.10	.....	.....	.....	.....	.....	.....	.....	.....
"	30	.25	.....	.....	.....	.....	.....	.....	.....	.....
Total rainfall by months	.....	3.15	.....	4.50	.....	1.56	.....	.....	.....	.....
Variation from the normal at station	.....	—.11	.....	+1.96	.....	—.89	.....	.....	.....	.....
Upper Sandusky	3	.51	2	.27	4	.92	4	1.55	5	.35
"	14	1.02	3	.79	5	.35	11	.86	9	1 35
"	15	.11	8	1.00	17	.96	17	.58	22	.35
"	17	.42	16	.10	21	.57	21	.78	26	.20
"	18	.50	18	.90	22	20	26	.27	29	.25
"	20	.80	24	.65	24	.10	.....	.....	.....	.....
"	25	.21	.....	.....	30	.55	.....	.....	.....	.....
"	27	.15	.....	.....	.....	.....	.....	.....	.....	.....
"	28	.30	.....	.....	.....	.....	.....	.....	.....	.....
Total rainfall by months	.....	4.11	.....	3.78	.....	3.64	.....	4.03	.....	3.50
Variation from the normal at station	.....	+.99	.....	+1.07	.....	+1.15	.....	+1.79	.....	+.25
Tiffin	17	.24	3	.68	4	2.69	4	1.54	5	.47
"	20	.68	8	1.18	6	.64	5	.66	9	1.23
"	25	.10	16	1.08	15	.31	11	.48	10	.61
"	29	.60	17	1.44	22	.47	18	.32	26	.25
"	30	.29	18	2.26	24	.29	21	.20	.....	.....
"	.....	.....	24	.65	2.	.35	22	.58	.....	.....
"	.....	.....	.....	.....	.....	.....	26	.28	.....	.....
"	.....	.....	.....	.....	.....	.....	30	.12	.....	.....
Total rainfall by months	.....	2.06	.....	7.42	.....	4 89	.....	4.80	.....	2.97
Variation from the normal at station	.....	+1.49	.....	+4.61	.....	+2.83	.....	+1.70	.....	—.45
Vickery	4	.32	3	.71	4	1.16	4	2.82	5	.35
"	17	2 50	8	.30	6	.35	5	.50	9	1 22
"	19	.15	12	.18	15	.32	11	.90	10	.30
"	20	.36	17	1.72	18	.10	18	.35	26	.16
"	24	.22	24	.28	22	.27	21	.50	.....	.....
"	25	.75	.....	.....	23	.61	22	.44	.....	.....
"	28	.41	.....	.....	24	.14	26	.15	.....	.....
"	30	1.50	.....	.....	.....	.....	.....	.....	.....	.....
Total rainfall by months	.....	6.75	.....	3.60	.....	2.99	.....	5.28	.....	2.72
Variation from the normal at station	.....	+2 65	.....	+1.77	.....	+.66	.....	+2.61	.....	—.49
Average for whole basin by months	.....	4.02	.....	4.82	.....	3.27	.....	4 54	.....	3.06
Average variation from normal for the whole basin	.....	+2.04	.....	+2.85	.....	+.94	.....	+2.03	.....	—.23

Maumee River Basin.

Station.	July.	Rain.	August.	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
Findlay	3	.19	2	.21	4	1.72	3	.19	5	.67
"	8	.74	3	.11	5	.29	4	1.62	8	.60
"	14	.15	7	1.62	14	.34	10	.24	9	1.08
"	16	.32	8	.15	17	.21	11	.18	10	.21
"	25	.38	11	.12	22	.97	14	.16	26	.32
"	28	.28	16	1.52	24	.10	17	.35	.....	.....
"	29	1.06	18	.28	29	.15	20	.35	.....	.....
"	.....	.....	25	1.07	.....	.....	21	.55	.....	.....
"	.....	.....	.....	.....	.....	.....	25	.38	.....	.....
Total rainfall by months	.....	3.20	.....	5.08	.....	3.90	.....	4.04	.....	3.18
Variation from the normal at station	.....	—.98	.....	+2.81	.....	+1.62	.....	+2 02	.....	—.89
Benton Ridge	3	.30	3	.22	4	.96	4	1.35	5	.69
"	15	.34	8	2.00	5	.18	11	.36	9	1.00
"	17	.17	16	.75	6	.20	14	.10	10	.60
"	19	.11	17	1.08	15	.53	18	.35	13	.10
"	25	.27	18	.15	22	.18	21	.36	26	.20
"	28	.20	24	.50	28	.57	22	.34	28	.15
"	29	.51	.....	.....	24	.18	.....	.....	.....	.....
"	30	.22	.....	.....	.....	.....	.....	.....	.....	.....
"	31	.14	.....	.....	.....	.....	.....	.....	.....	.....
Total rainfall by months	.....	2.84	.....	4 78	.....	2.75	.....	2.89	.....	2.83
Variation from the normal at station	.....	—1 16	.....	+1.21	.....	+.67	.....	+1.04	.....	—.62
Ottawa	15	.79	8	1.89	4	.67	4	1.11	5	.47
"	17	.13	12	.30	5	.12	5	.10	9	.98
"	19	.12	16	.24	6	.19	11	.74	10	63
"	25	.79	17	1.21	14	.10	14	.15	26	.25
"	28	.81	24	.35	15	.11	18	.40	29	.12
"	29	.98	.....	.....	22	.35	21	.30	.....	.....
"	30	.25	.....	.....	24	.88	22	.34	.....	.....
"	.....	.....	.....	.....	30	.85	26	.44	.....	.....
Total rainfall by months	.....	3.85	.....	3.75	.....	3.33	.....	3.71	.....	2.66
Variation from the normal at station	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Van Wert	.....	.....	8	1.00	4	.96	4	.33	5	.44
"	.....	.....	16	.34	5	.26	22	1.28	9	1.40
"	.....	.....	17	1.96	6	.54	30	.65	10	.60
"	.....	.....	29	.24	22	.34	.....	.....	26	.20
"	.....	.....	.....	.....	23	.20	.....	.....	28	.20
"	.....	.....	.....	.....	24	1.68	.....	.....	.....	.....
Total rainfall by months	.....	.....	.....	3 61	.....	4 04	.....	2.76	.....	2.84
Variation from the normal at station	.....	.....	.....	+1.23	.....	+1.48	.....	+1.38	.....	—.56
Hedges	3	.11	3	.43	23	1.28	11	.21	5	.11
"	24	.21	7	.48	29	.28	14	.19	8	.31
"	27	.28	8	.73	.....	.....	17	.32	9	.68
"	28	.69	.....	.....	.....	.....	18	.19	10	.98
"	30	.93	.....	.....	.....	.....	22	.18	25	.10
"	.....	.....	.....	.....	.....	.....	25	.39	26	.30
"	.....	.....	.....	.....	.....	.....	.....	.....	28	.40
Total rainfall by months	.....	2.85	.....	1.80	.....	1.80	.....	1.76	.....	2.87
Variation from the normal at station	.....	+ 08	.....	—.77	.....	—.80	.....	+.83	.....	+.30

MAUMEE RIVER BASIN—Continued.

Station.	July.	Rain.	August.	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
New Bremen	4	.12	1	10	4	.48	.....	.....	.....	.....
"	17	.74	8	.60	6	.19	.....	.....	.....	.....
"	18	.80	8	1.00	26	.10	.....	.....	.....	.....
"	19	.26	16	.14	.....	.....	.....	.....	.....	.....
"	25	.87	18	.16	.....	.....	.....	.....	.....	.....
"	28	.23	29	.29	.....	.....	.....	.....	.....	.....
"	30	.31	.....	.....	.....	.....	.....	.....	.....	.....
Total rainfall by months	.....	3.33	.....	2.29	.....	.88	.....	.....	.....	.....
Variation from the normal at station	.....	−1.20	.....	+.02	.....	−1.66	.....	.....	.....	.....
Montpelier	17	.96	3	.17	1	.11	11	1 40	5	.60
"	18	.78	7	.19	5	.59	19	.78	9	.89
"	19	.18	8	.20	6	.79	21	.38	10	.51
"	25	.77	9	.16	15	.47	26	.54	11	.35
"	28	2.15	24	.52	21	1.50	30	.12	26	.25
"	30	.72	26	.14	.....	.....	.....	.....	29	.56
Total rainfall by months	.....	5.46	.....	1.38	.....	3.46	.....	3.22	.....	3.16
Variation from the normal at station	.....	+2.05	.....	−1.40	.....	−.99	.....	+1.61	.....	−.54
Auburn	18	.48	3	.16	5	.29	1	.21	5	.61
"	20	.17	4	.24	6	1.00	31	3.65	8	.20
"	24	2.05	8	1.25	23	.88	.....	.....	9	.94
"	25	.43	9	.15	25	1.40	.....	.....	10	.69
"	29	.44	24	.45	29	.18	.....	.....	23	.13
"	30	1.03	25	.15	.....	.....	.....	.....	26	.22
Total rainfall by months	.....	4.67	.....	2.50	.....	3 41	.....	3.89	.....	3.08
Variation from the normal at station	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fort Wayne	17	.45	2	.15	4	.50	1	.15	5	.78
"	18	.40	3	.86	6	1.58	4	.10	8	.29
"	24	.96	8	.99	15	.92	11	2.21	9	1.01
"	25	.36	*	.....	17	.19	14	.46	10	.58
"	28	.63	.....	.....	22	1.15	17	.44	22	.20
"	29	.70	.....	.....	24	.52	21	16	26	.30
"	30	.81	.....	.....	29	.18	22	.12	28	.15
"	.....	.....	.....	.....	.....	.....	25	.45	29	.16
"	.....	.....	.....	.....	.....	.....	30	.15	.....	.....
Total rainfall by months	.....	4.40	.....	.....	.....	5.26	.....	4.32	.....	3.56
Variation from the normal at station	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Defiance	19	.27	3	.18	4	.25	1	.11	5	.64
"	20	.24	8	.81	5	.15	4	.59	9	1.54
"	23	.98	9	.21	6	.24	11	1.37	10	.55
"	28	1.21	19	.21	7	1.10	18	.66	26	.20
"	29	1.38	25	.47	15	.58	21	.20	.....	.....
"	30	1.11	.....	.....	18	.15	22	.45	.....	.....
"	.....	.....	.....	.....	23	.64	25	.15	.....	.....
"	.....	.....	.....	.....	24	.13	26	.26	.....	.....
"	.....	.....	.....	.....	25	.86	30	.12	.....	.....
"	.....	.....	.....	.....	29	.68	31	.20	.....	.....
Total rainfall by months	.....	5.44	.....	2 01	.....	4.92	.....	3.80	.....	3.20
Variation from the normal at station	.....	+1.51	.....	−.37	.....	+2.41	.....	+1.84	.....	−.37

* Not obtainable after the 16th.

MAUMEE RIVER BASIN—Concluded.

Station.	July.	Rain.	August.	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
Ridgeville Corners	18	.15	3	.23	4	.23	4	.24	5	.69
"	19	.41	18	.80	5	.16	11	.90	8	.13
"	20	.16	24	.50	6	.76	18	.56	9	.93
"	25	1.14	.....	.....	15	.40	21	.16	10	.77
"	28	.78	.....	.....	16	.17	22	.45	26	.27
"	29	.13	.....	.....	18	.23	25	.11	29	.15
"	30	.67	.....	.....	22	.21	26	.47	.....	.....
"	.....	.....	.....	.....	23	.23	.....	.....	.....	.....
"	.....	.....	.....	.....	24	.77	.....	.....	.....	.....
"	.....	.....	.....	.....	29	.23	.....	.....	.....	.....
Total rainfall by months	.....	3.44	.....	1.64	.....	3.39	.....	2.89	.....	2.96
Variation from the normal at station	.....	—.44	.....	—.74	.....	+1 05	.....	+1.68	.....	—.64
Napoleon	19	.20	3	.23	4	.51	4	.65	5	.52
"	25	1.00	8	.51	5	.10	11	.85	9	1.05
"	27	.50	17	.15	6	1.05	18	.53	10	.60
"	28	1.57	18	1.60	14	.67	21	.15	26	.40
"	30	.78	19	.17	22	.23	26	.53	.....	.....
"	.....	.....	24	.13	23	.60	.....	.....	.....	.....
"	.....	.....	.....	.....	24	.20	.....	.....	.....	.....
"	.....	.....	.....	.....	29	.45	.....	.....	.....	.....
"	.....	.....	.....	.....	30	.15	.....	.....	.....	.....
Total rainfall by months	.....	4.09	.....	3.09	.....	3.96	.....	2.71	.....	2 65
Variation from the normal at station	.....	+.33	.....	+1.63	.....	+1.55	.....	+.95	.....	—.30
Wauseon	16	.71	3	.30	4	.15	10	.17	5	.58
"	17	.72	7	.24	5	.19	11	1.07	8	.22
"	18	.86	8	.11	6	.62	18	.61	9	1.22
"	19	.10	17	.22	15	.16	21	.19	10	.70
"	25	1.15	18	.32	17	.12	22	.36	26	.18
"	28	.60	24	.46	22	.23	25	.34	28	.10
"	30	.67	.....	.....	23	.11	26	.29	.....	.....
"	.....	.....	.....	.....	24	1.11	.....	.....	.....	.....
"	.....	.....	.....	.....	29	.40	.....	.....	.....	.....
Total rainfall by months	.....	4.91	.....	2.24	.....	3.72	.....	3.42	.....	3.39
Variation from the normal at station	.....	+1.16	.....	—.49	.....	+ 75	.....	+1.05	.....	+.13
Neapolis	16	.34	3	.60	6	1.13	4	.48	5	.54
"	19	.30	7	.20	14	.12	5	.10	8	.30
"	25	1.75	8	.30	18	.35	11	1.10	9	.30
"	28	.67	12	.20	22	.43	18	.58	10	.65
"	30	.70	17	.35	23	.41	21	.25	26	.35
"	.....	.....	18	.15	24	1.10	22	.42	.....	.....
"	.....	.....	24	.26	.....	.....	26	.46	.....	.....
"	.....	.....	27	.15	.....	.....	.....	.....	.....	.....
Total rainfall by months	.....	3.78	.....	2.24	.....	4.27	.....	3.34	.....	2.69
Variation from the normal at station	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Toledo	17	.67	7	.38	4	.30	4	.41	5	.29
"	19	.26	8	.16	5	.12	11	.98	8	.21
"	25	1.18	12	.15	6	.24	18	.32	9	.66
"	28	.70	17	.16	15	.20	21	.24	10	.63
"	30	.40	24	.36	18	.14	22	.41	26	.20
"	.....	.....	.....	.....	23	.40	26	.25	.....	.....
"	.....	.....	.....	.....	24	.30	.....	.....	.....	.....
1 by months	.....	3.30	.....	1.82	.....	1.81	.....	2.81	.....	2.21
from the normal at station	.....	+.13	.....	—.88	.....	—.56	.....	+.46	.....	—.68
Average for whole basin by months	.....	3.90	.....	2.72	.....	3.36	.....	3.22	.....	2.94
Average variation from the normal for whole basin	.....	+.15	.....	+.20	.....	+.55	.....	+1.28	.....	—.37

The following general statements were also taken from the monthly reports of the United States Weather Bureau, Ohio Section.

July. The temperature was 2.8°F. above the normal, and the precipitation was .40 above the normal. The precipitation in the northern section was .73 above the normal.

August. The temperature was 2.2° F. above the normal. The precipitation was 1.65 above the normal.

September. The temperature was 2 5° F. above the normal. While the precipitation for the State was .04 below the normal, the northern section gave a precipitation of .12 above the normal.

October. The temperature was 2.0°F. above the normal, and the precipitation was 1.68 above. The excess of precipitation for the northern section was 1.99.

November. Temperature, 1.8°F. below the normal. Precipitation, .21 below the normal, although the northern section had a precipitation .11 above the normal.

From these sources we derive the following weather history of the samples. A precipitation of less than one-half inch in twenty-four hours is spoken of as a light rain; from one-half to one inch as moderate, and greater than one inch as heavy.

SANDUSKY RIVER.

July samples. These were taken on the 14th, 15th and 16th of the month, and represent the river after a period of hot, dry weather, as July gave an excess of temperature of nearly 3°F. The samples were taken after a long drouth, as practically no rain had fallen in July previous to the time the samples were taken. The table shows a heavy local rain at Upper Sandusky on July 14, but the rain fell after our samples were taken.

August samples. Taken August 9-11. These again represent excessive hot weather conditions, but differ from the preceding in relation to precipitation influences. On the 3d a moderate rain prevailed over the entire watershed, while the 8th and 9th gave moderate rains at Bucyrus and Vickery, with heavy rains at Upper Sandusky and Tiffin. Little influence would be felt from the rain of the 3d, but the rains preceding the collection by only a day or two would exert considerable influence. Accordingly these samples represent the river directly after moderate to heavy rains, although the weather was fair at the time of sampling.

September samples. The September collections were made on the 19th to 21st of the month and again show fair weather conditions. The lower part of the watershed received a heavy rain on the 4th, and moderate rains on the 6th and 15th, but these would affect the samples only

indirectly. At Upper Sandusky there occurred a light rain on the 5th, and moderate rains on the 4th and 17th. The table shows no rain of moment in the upper part on the watershed for nearly four weeks preceding the September sampling, but the collector's note book says: "Rain fell at Bucyrus September 17 and 18, resulting in roily water."

October samples. These were taken during another fair weather period, as the samples were collected on the 10th, 11th and 12th. The only rain in the month previous to these dates was a heavy one on the 4th and 5th. A moderate rain fell on the 11th, during the time of collection, but would affect only the Tiffin and Fremont samples.

November samples. The November samples were collected on the 9th and 10th. The only rainfall for two weeks previously, as shown by the table, was on the 5th, so we have samples taken after a season of fair weather, but it should be borne in mind that on the two days covering the period of sampling there occurred the heaviest general rain of any forty-eight hours in succession that occurred during the time we had the river under consideration. Two thirds of the rainfall of the entire month fell on these two days, and every sample on the trip was taken in a steady rain. Thus it will be seen that the November samples represent the river at the very beginning of a hard rain, which would bring the stream to flood height. By the time the last stations were reached—Bucyrus, above and below—the stream was overflowing its banks. The results indicate the addition of this amount of rain water, with its attendant surface washings.

MAUMEE RIVER.

July samples. Samples were taken on the 21st–23d of the month. General light or moderate rains had fallen in all parts of the watershed between the 17th and 20th. Previous to these rains there had been a period of drought. No rain fell during the period of sampling. On the 21st the health officer of Findlay informed the collector that on the day preceding, a heavy rain occurred up the river, causing the river to rise eight inches.

August samples. The August samples were collected on the 23d, 24th and 25th. The samples from Ft. Wayne and from Defiance above on the Maumee represent the condition of the water in summer after a long drought, as no rain of moment had fallen on that part of the watershed for sometime. There were, however, one week previous to the time of sampling, heavy rains on the area drained by the Blanchard and Ottawa rivers, with a heavy rain at Napoleon and a light one at Toledo. On the 24th and 25th occurred moderate or heavy rains to affect the following samples: Defiance, Napoleon, and Toledo slightly, while a heavy

rain of 1.07 inches fell within the twenty-four hours preceding the taking of the Findlay samples.

September samples. The date of the September sampling was from the 26th to 28th. This was a period of fair weather. The month in general had been wet and culminated in a severe rain on or about the 24th. In some localities a severe wind accompanied this storm, as at Lima. Accordingly these samples represent wet weather conditions followed by a few days of fair weather.

October samples. In October the samples were taken on the 24th, 25th and 26th, representing the river after considerable wet weather. The streams were higher than in September, but had not risen so suddenly, nor were the waters so high as in the succeeding month.

November samples. The November samples showed the river in by far the highest stage examined. The samples were taken on the 14th to the 16th. Although the precipitation for Ohio for November was .21 inch below the normal, yet the northern section gave an excess of .11 inch, and furthermore, nearly all the rainfall of the month occurred between the 5th and 11th. The weather was cold, especially so during the time of sampling. This high stage of the river continued for some days, and gave results not obtainable in the warmer season of the year, and the dryer months.

LIST OF SAMPLES.

Following is a list of samples taken, with the serial number, location, source, date and hour of collection:

1	Upper Sandusky,	below,	Sandusky river,	July 14,	8:15	A. M.
2	"	above	"	"	9:15	A. M.
3	Bucyrus,	"	"	"	2:15	P. M.
4	"	below	"	"	3:15	P. M.
5	Crestline, 2 miles	"	"	"	6:00	P. M.
6	" 3 "	"	"	"	7:00	P. M.
7	Tiffin,	above	"	July 15,	8:30	A. M.
8	"	below	"	"	10:00	A. M.
9	Fremont,	above	"	"	6:00	P. M.
10	"	below	"	"	6:45	P. M.
11	Sandusky,	intake,	Sandusky bay,	July 16,	9:15	A. M.
12	Findlay,	above,	Blanchard river,	" 21,	10:00	A. M.
13	"	below	"	" 21,	10:45	A. M.
14	Lima,	above,	Ottawa river,	" 21,	3:15	P. M.
15	"	below	"	" 21,	4:30	P. M.
16	Ft. Wayne,	"	Maumee river,	July 22,	9:00	A. M.
17	"	above,	St. Marys "	" 22,	10:30	A. M.
18	Defiance,	"	Maumee "	" 22,	1:30	P. M.
19	"	"	Auglaize "	" 22,	2:45	P. M.

20	Defiance,	below,	Maumee	river,	July	22,	4:00 P. M.
21	Napoleon,	above	"	"	"	23,	6:45 A. M.
22	"	below	"	"	"	23,	8:00 A. M.
23	Toledo,	above	"	"	"	23,	2:30 P. M.
24	" Cherry street,		"	"	"	23,	3:45 P. M.
25	" Riverside Park,		"	"	"	23,	4:15 P. M.
26	Upper Sandusky,	below,	Sandusky	"	Aug.	9,	8:15 A. M.
27	" "	above	"	"	"	9,	9:15 A. M.
28	Bucyrus,	"	"	"	"	9,	1:45 P. M.
29	"	below	"	"	"	9,	2:45 P. M.
30	Crestline,	"	"	"	"	9,	6:00 P. M.
31	Tiffin,	above	"	"	"	10,	8:30 A. M.
32	"	below	"	"	"	10,	10:00 A. M.
33	Fremont,	"	"	"	"	10,	4:30 P. M.
34	"	above	"	"	"	10,	5:30 P. M.
35	Sandusky,	intake	"	bay,	"	11,	9:15 A. M.
36	Ft. Wayne,	below,	Maumee	river,	"	23,	5:00 P M.
37	"	above,	St. Joseph	"	"	23,	6:00 P. M.
38	"	"	St. Mary	"	"	23,	7:00 P. M.
39	Lima,	below,	Ottawa	"	"	24,	9:00 A. M.
40	"	above	"	"	"	24,	11:00 A. M.
41	Defiance,	"	Maumee	"	"	24,	3:45 P. M.
42	"	"	Auglaize	"	"	24,	4:30 P. M.
43	"	below,	Maumee	"	"	24,	5:30 P. M.
44	Napoleon,	above	"	"	"	25,	6:15 A. M.
45	"	below	"	"	"	25,	7:15 A. M.
46	Toledo, Riverside Park,		"	"	"	25,	10:00 A. M.
47	" Cherry street,		"	"	"	25,	10:30 A. M.
48	"	above	"	"	"	25,	12:00 M.
49	Findlay,	below,	Blanchard	"	"	25,	4:15 P. M.
50	"	above	"	"	"	25,	5:15 P. M.
51	Upper Sandusky,	below,	Sandusky	"	S pt.	19,	8:00 A. M.
52	" "	above	"	"	"	19,	9:00 A. M.
53	Crestline,	below	"	"	"	19,	11:30 A. M.
54	Bucyrus,	"	"	"	"	19,	2:00 P. M.
55	Bucyrus,	above	"	"	"	19,	3:00 P. M.
56	Tiffin	"	"	"	"	20,	1:30 P. M.
57	"	below	"	"	"	20,	2:00 P. M.
58	Fremont,	"	"	"	"	20,	4:30 P. M.
59	"	above	"	"	"	20,	5:30 P. M.
60	Sandusky,	intake	"	bay,	"	21,	8:30 A. M.
61	Findlay,	below,	Blanchard	river,	"	26,	9:30 A. M.
62	"	above	"	"	"	26,	10:30 A. M.
63	Lima,	below,	Ottawa	"	"	26,	5:00 P. M.
64	"	above	"	"	"	26,	6:00 P M.
65	Ft. Wayne,	below,	Maumee	"	"	27,	8:30 A. M.
66	"	above,	St. Joseph	"	"	27,	9:30 A. M
67	"	"	St. Mary	"	"	27,	10:30 A. M

68	Defiance,	above,	Maumee	river,	Sept.	27,	1:15 P. M.
69	"	"	Auglaize	"	"	27,	2.00 P. M.
70	"	below,	Maumee	"	"	27,	3:00 P. M.
71	Napoleon,	above	"	"	"	28,	7:00 A. M.
72	"	below	"	"	"	28,	8:00 A. M.
73	Toledo, Cherry street,		"	"	"	28,	1:15 P. M.
74	" Riverside Park,		"	"	"	28,	2:00 P. M.
75	"	above	"	"	"	28,	3:00 P. M.
76	Upper Sandusky,	below,	Sandusky	"	Oct.	10,	7:45 A. M.
77	" "	above	"	"	"	10,	8:45 A. M.
78	Bucyrus,	"	"	"	"	10,	10:30 A. M.
79	"	below	"	"	"	10,	11:30 A. M.
80	Crestline,	"	"	"	"	10,	2:15 P. M.
81	"	above	"	"	"	10,	3:15 P M.
82	Tiffin,	below	"	"	"	11,	3:00 P. M.
83	"	above	"	"	"	11,	4:00 P. M.
84	Sandusky,	intake,	Sandusky bay,		"	12,	9:30 A. M.
85	Fremont,	below	"	river,	"	12,	1:00 P. M.
86	"	above	"	"	"	12,	2:00 P. M.
87	Findlay,	below,	Blanchard	"	"	24,	9:30 A. M.
88	"	above	"	"	"	24,	10:30 A. M.
89	Lima,	below,	Ottawa	"	"	24,	4:30 P M.
90	"	above	"	"	"	24,	5:15 P. M.
91	Ft. Wayne,	below,	Maumee	"	"	25,	8:30 A. M.
92	"	above,	St. Joseph	"	"	25,	9:30 A. M.
93	"	"	St Mary	"	"	25,	10:30 A. M.
94	Defiance,	"	Maumee	"	"	25,	2:00 P. M.
95	"	"	Auglaize	"	"	25,	2:30 P. M.
96	"	below,	Maumee	"	"	25,	3:15 P. M.
97	Napoleon,	above	"	"	"	26,	6:30 A. M.
98	"	below	"	"	"	26,	7:15 A. M.
99	Toledo, Cherry street,		"	"	"	26,	11:00 A. M.
100	"	above	"	"	"	26,	1:00 P. M.
101	" Riverside Park,		"	"	"	26,	3:00 P. M.
102	Upper Sandusky,	below,	Sandusky	"	Nov.	9,	7:45 A. M.
103	" "	above	"	"	"	9,	8:30 A. M.
104	Crestline,	below	"	"	"	9,	10:30 A. M.
105	"	above	"	"	"	9,	11:30 A. M.
106	Tiffin,	below	"	"	"	9,	2:30 P. M.
107	"	above	"	"	"	9,	3:30 P. M.
108	Fremont,	"	"	"	"	10,	5:45 A. M.
109	"	below	"	"	"	10,	6:30 A. M.
110	Sandusky,	intake,	Sandusky bay,		"	10,	9:15 A. M.
111	Bucyrus,	above	"	river,	"	10,	1:30 P. M.
112	"	below	"	"	"	10,	2:30 P. M.
113	Findlay,	"	Blanchard	"	"	14,	9:30 A. M.
114	"	above	"	"	"	14,	10:30 A. M.
115	Toledo, Riverside Park,		Maumee	"	"	14,	3:00 P. M.

116	Toledo, Cherry street,		Maumee	river,	Nov.	14,	4:00 P. M.
117	"	above	"	"	"	14,	5:00 P. M.
118	Napoleon,	"	"	"	"	15,	5:30 A. M.
119	"	below	"	"	"	15,	6:00 A. M.
120	Defiance,	above,	Auglaize	"	"	15,	3:00 P. M.
121	"	below,	Maumee	"	"	15,	3:30 P. M.
122	"	above	"	"	"	15,	4:30 P. M.
123	Ft Wayne,	"	St. Joseph	"	"	16,	6:00 A. M.
124	"	below,	Maumee	"	"	16,	7:00 A. M.
125	"	above,	St. Mary	"	"	16,	8:00 A. M.
126	Lima,	below,	Ottawa	"	"	16,	1:00 P. M.
127	"	above	"	"	"	16,	2:00 P. M.

It will be seen that samples 11, 35, 60, 84 and 110 are from Sandusky bay at the intake, where the public supply is obtained for Sandusky. The stations above Bucyrus, Upper Sandusky, Findlay, Defiance, Napoleon, Toledo, and at Sandusky, were at or near the intake, and the results indicate the quality of the water supply at those places. The same is true of Tiffin, Fremont and Lima, with the exception that a part of their supplies is obtained from ground sources. The July sample below Upper Sandusky was, through a misunderstanding, taken above part of the local pollution. The later samples were taken about half a mile lower down the stream. The samples of the later four months below Defiance, and above Napoleon, were taken from the opposite bank of the river than were the July samples, owing to the difficulty in reaching the points where the first samples were taken. The July, Toledo, Cherry street sample, was taken from a dock, but the later samples were taken from the channel of the stream by means of a row boat.

RESULTS OF THE ANALYSES.

The results of the analyses of samples from the Sandusky and Maumee watersheds for the five months, July to November, 1898, are given, first in tabulated form, and second by curves. In the table, the first column gives the station numbers. These commence at the headwaters and are arranged geographically along the course of the river to its mouth. In each case the station number, unaccompanied by a subscript letter represents the station above the local pollution, while the number with a subscript letter shows a station below local pollution. When more than one station occurs below local pollution (e. g. Toledo) the subscript letters show alphabetically the relative location of the station, "a" being nearer the headwaters of the stream than "b". Where two stations occur at any city above the local pollution, they are situated on different streams and are distinguished by subscript numerals. The

second column gives the serial number of the sample as collected. The third column gives in miles the approximate distance by river from the uppermost station taken. The fourth and fifth columns give respectively the locality and the date of sampling. Then follow the analytical results, the figures representing parts per million (milligrams per litre), except in the case of color, dissolved oxygen, bacteria and temperature, as explained previously. In plotting the curves, horizontal spaces represent dist nces by river, while vertical spaces represent the amounts present of the substance in question. Naturally, the vertical scale varies according to the substance plotted. The samples were collected as nearly once a month as other laboratory work would permit.

SANDUSKY WATERSHED.

Sandusky River.

(Parts per million.)

Station	Sample number.	Approximate distance.	Location of sample.	Date collected. Month.	Day.	Color.	Turbidity.	Sediment.	Odor.	Oxygen required.
1	21	.....	Crestline, above town	Oct.	10	.25	Dis.	V. S.	None	6.80
	105		" "	Nov.	9	.40	Dec.	C.	Woody	8.74
			Average			.32				7.67
	5	2	Crestline, below town	July	14	1.00	Dis.	C.	Foul	11.45
	20		" "	Aug.	9	.40	Dis.	C.	Foul	10.84
	53		" "	Sept.	19	.60	Dec.	C.	Very musty	7.38
	83		" "	Oct.	10	.30	Dis.	C.	Foul	11.95
	104		" "	Nov.	9	.60	Dec.	C.	Foul, earthy	11.17
			Average			.58				10.58
1b	6	3	Crestline, below town	July	14	.10		S.	Slight musty	4.55
2	3	17	Bucyrus, above town	July	14	.10	S.	S.	None	4.45
	35		" "	Aug.	9	.3	Dis.	S.	Faint musty	6.65
	54		" "	Sept.	19	.25	S.	S.	None	5.98
	78		" "	Oct.	10	.42	Dis.	S.	Faint musty	7.96
	111		" "	Nov.	10	.5	Dec.	C.	Earthy	9.54
			Aver			.31				6.88
	4	30	Bucyrus, below town	July	14	.20	Dec.	M.	Very foul	8.27
	30		" "	Aug.	9	.5	Dis.	S.	Very offensive	6.41
	52		" "	Sept.	19	.5	S.	C.	Sour	7.39
	72		" "	Oct.	10	.15	Dis.	S.	Musty	9.88
	112		" "	Nov.	10	.5	Dec.	C.	Earthy	7.67
			Average			.71				7.76
3	2	42	Upper Sandusky, above	July	14	.8	S.	S.	Woody	5.77
	32		" "	Aug.	9	.15	S.	S.	Woody	5.36
	52		" "	Sept.	19	.15	S.	S.	None	6.11
	77		" "	Oct.	10	.4	Dis.	S.	Woody	5.15
	103		" "	Nov.	9	.45	Dec.	C.	Earthy	7.56
			Average			.25				6.31
	1*	44	Upper Sandusky, below	July	14	.1	S.	S.	Musty	4.02
	36		" "	Aug.	9	.15	S.	S.	Offensive	6.02
	51		" "	Sept.	19	.15	S.	S.	Musty	4.26
	78		" "	Oct.	10	.4	Dis.	S.	Musty	7.36
	102		" "	Nov.	9	.5	Dec.	C.	Earthy	8.89
			Average			.30				6.56
4	7	74	Tiffin, above town	July	15	.1	S.	S.	Peculiar	4.35
	33		" "	Aug.	10	.35	Dec.	S.	Woody	10.39
	56		" "	Sept.	20	.15	V. S.	S.	Woody	5.23
	82		" "	Oct.	11	.5	Dis.	S.	Woody	5.13
	107		" "	Nov.	9	.5	Dec.	C.	Earthy	7.88
			Average			.35				7.16

* Sample No. 1 was not taken below all local sewage pollution.

SANDUSKY WATERSHED.

Sandusky River.

(Parts per million.)

Albuminoid ammonia.	Nitrogen as			Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved Oxygen—Per cent. saturation.	Bacteria per C. C.	Temperature ° C.
	Free ammonia.	Nitrites.	Nitrates.								
0.198	0.082	.008	0.192	8.6	188 1	46.4	478	122	128.0	1,160	21.5
0.688	0.048	Trace.	0.331	1.2	39.0	11.4	332	65	77.5	58,500	8.
0.443	0.040	.002	0.262	4.9	111.0	28.9	405	94	100.0	29,830	....
0.454	0.530	.400	7.944	198.8	308.4	7.7	877	126	83.0	65,850	26.
0.516	0.780	.250	0.228	63.5	225.4	128.2	748	141	26.5	30,210	23.
0.440	0.680	.250	6.220	24.8	152.2	98.5	628	162	62.9	46,800	20.5
0.456	0.896	.060	3.036	83 1	327.8	85.6	675	148	43.5	18,095	20.
0.812	0.152	.025	0.461	7.4	68.9	27.4	625	117	40.0	222,300	8.
0.536	0.608	.195	3.577	75.4	215.5	58.5	710	138	51.2	76,551	....
0.219	0.094	.001	0.318	12.7	146.4	51.7	467	92	Not tak'n	Not tak'n	Not tak'n
0.190	0.088	Trace.	0 262	11.8	172.4	10.4	402	74	124.0	345	30.5
0.240	0.082	.018	0 064	17,7	118 8	82.0	372	80	114.5	775	25.
0.212	0 064	.005	0.232	16.2	150.9	42 4	334	96	109.8	735	25.
0.226	0.088	.008	0 180	12.0	172.1	28 4	326	85	87.4	200	16.5
0.476	0.089	Trace.	0.418	8.7	60.0	None.	491	68	81.7	82,800	8.
0.229	0.051	.006	0.231	12.3	133.8	32.6	395	81	103.4	16,971	.....
0 636	0 784	.028	2.748	68.2	171.6	160.0	580	155	67 0	295,800	30.
0.420	0.460	.087	0.166	24.2	137.4	58.4	378	82	72.3	29,260	25.5
0.272	0.144	.018	0.296	14.2	169.0	35.8	379	68	94 0	24,070	24.
0.404	0 548	.015	1 328	16.4	176.6	42.6	548	169	79 4	5 331	18.
0 552	0.042	.004	0.331	4 5	55.5	None.	348	51	62.8	175 000	8.
0.457	0.396	.029	0.974	24.5	142.0	58.3	450	104	75.1	105,902	.. ..
0.192	0.082	.006	0.250	11.5	133.4	124.2	528	133	79.0	167	25.
0.272	0.064	.008	0 054	24.6	144 4	83.6	419	115	88.3	677	23.
0.176	0.050	.004	0.224	4.0	138.2	71.8	429	8	86.5	1,300	20.5
0.192	0.046	.002	0.080	16.6	158.6	64.4	367	107	94.8	585	15.5
0.560	0.076	.005	0.258	6.7	121,1	38.4	321	115	86.8	13,100	7.5
0.278	0.064	.003	0.185	12.7	139.1	76.5	413	110	85.9	3,166	.....
0.194	0.104	.009	0.318	13.8	155.2	134.7	777	353	47 0	610	24.
0.302	0.112	.025	0.152	28 4	147.6	88.8	501	131	61.7	8,440	22 8
0.312	0.132	.040	0.248	10.1	151.8	99.5	482	56	54.6	40,320	19.
0.248	0.080	.010	0 244	12 8	174.7	55.4	428	87	76.0	5,070	14 5
0.592	0.104	.006	0.274	7.1	118.5	35 0	310	51	77.7	81,900	7.5
0.330	0.106	.018	0.247	14.4	148.6	82.7	499	138	63.4	17,268	.....
0.190	0.144	.002	0.248	103.5	170.4	96.8	712	282	95.0	188	27.
0.280	0.058	.008	0.080	15.2	71.6	56.4	340	75	59.1	1,590	28
0 148	0 042	.010	0.192	32.8	160.6	86.8	495	94	115.5	820	22.5
0.234	0 034	.001	0.152	150.1	186.6	76 2	734	160	80.9	1,155	18.
0.592	0.116	Trace	0.234	20.3	126.8	24.0	461	57	79.7	16,980	7.
0.289	0.079	.004	0.177	64.4	143.2	67.9	548	124	86.0	4,134	.....

SANDUSKY WATERSHED—Concluded.

SANDUSKY RIVER—Concluded.

(Parts per million.)

Station.	Sample number.	Approximate distances.	Location of sample.	Date collected. Month.	Day.	Color	Turbidity.	Sediment.	Odor.	Oxygen required.
4a	8	77	Tiffin, below town	July	15	.2	S.	S.	Bad, musty	4 25
	32		" "	Aug.	10	.65	Dec.	S	Sour	10.67
	57		" "	Sept.	20	.55	V. S.	S.	Sweetish	8.51
	82		" "	Oct.	11	.3	Dis.	S.	Musty	5.12
	106		" "	Nov.	9	.5	Dec.	C.	Earthy	8.79
			Average			.4				7.55
5	9	96	Fremont, above town	July	15	.15	S.	S.	None	4.27
	34		" "	Aug.	10	.55	Dis	S.	Slight musty	7.17
	59		" "	Sept.	20	.4	S.	S.	Slight musty	9.20
	86		" "	Oct.	12	.28	S.	S.	Slight musty	5.22
	108		" "	Nov.	11	.47	Dec.	C.	Earthy	9.31
			Average			.37				7.05
5a	10	96	Fremont, below town	July	15	.2	S.	S.	Faint musty	4.55
	33		" "	Aug.	10	.55	Dis.	S.	Musty	8.01
	58		" "	Sept.	20	.4	V. S	V. S.	Faint musty	9.07
	85		" "	Oct.	12	.3	Dis.	S.	Faint musty	6.46
	109		" "	Nov.	11	.47	Dec.	C.	Earthy	7.91
			Average			.38				7.20
6	11	125	Sandusky, crib	July	16	.05	V. S	V. S	Woody	2.82
	35		" "	Aug.	11	.1	S.	V. S	None	2.64
	60		" "	Sept.	21	.1	None	Trace	None	2 77
	84		" "	Oct.	12	.1	S.	S.	None	3 93
	110		" "	Nov.	10	.05	V. S.	S.	None	2.02
			Average			.08				2 74

SANDUSKY WATERSHED—Concluded.

SANDUSKY RIVER—Concluded.

(Parts per million.)

Nitrogen as											
Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen—Per cent. saturation.	Bacteria per C. C.	Temperature ° C.
0.248	0.128	.007	0.371	99.8	178.2	99.2	677	215	92.0	5,700	22.
0.428	0.084	.015	0.112	21.3	80 8	106.8	331	69	77.7	9,720	23.
0.336	0 280	.025	0.140	38.3	159.8	91.8	451	46	112.8	4,140	24.
0.352	0.108	.013	0.244	147.5	188 b	85.2	6b7	188	82.1	37,400	19.
0.656	0.128	.004	0.227	10.5	148.6	27 6	437	88	78.1	53,000	7.5
0.404	0.146	.013	0.219	63.5	148.2	82.1	513	120	87.4	21,992	.....
0.234	0.062	None.	0.200	99.2	125.0	20 2	595	186	94.0	330	22.5
0.358	0.078	.013	0 059	58.6	92.0	41 6	493	187	89.2	1,819	23.3
0.226	0.044	.008	0.160	33.1	126.4	61.2	468	75	86.8	675	21.5
0.172	0 022	.010	0 367	60.1	191.1	69 2	479	94	88.4	1,455	17.
0.664	0.080	Trace.	0.252	15 4	184 6	36.4	601	124	84.7	4,490	7.5
0.331	0.057	.005	0.207	52.3	133.8	45.7	527	123	88.6	1,654	.....
0 284	0.089	Trace.	0.364	102 5	133.2	26.1	577	186	98 0	4,725	29.
0.412	0.082	.016	0.062	61 0	100 2	112.2	410	91	74 8	11,060	25.7
0 281	0.144	.010	0.168	37 5	125 2	76.9	414	84	78.2	4,730	22.
0.256	0.116	.025	0.447	64.5	191.5	5?.4	368	110	78 0	11,400	17.
0.596	0.120	.006	0.220	22.1	148 0	35 0	522	109	77.5	5,060	7.5
0.386	0.110	.011	0.252	57.5	139.6	61.1	458	116	81.2	7,395	.....
0.131	0.042	.003	0.102	10 8	89.8	47 5	282	80	96.0	828	26.
0.160	0.044	.018	0.068	13.6	95 4	45 8	285	74	91.3	594	24.5
0.160	0.072	None.	0.040	8.9	100 6	36.2	221	35	89 9	115	19.
0.120	0 016	None.	0 049	11.2	105.8	36 6	264	47	78.6	1,680	16.
0.324	0 024	None.	0 126	4.7	106 8	36 0	206	21	79.9	359	8.
0.179	0.030	.003	0.077	9.8	99.7	40.4	238	51	87.1	614	.....

MAUMEE WATERSHED.

Blanchard River.

(Parts per million.)

Station.	Sample number.	Approximate distances.	Location of sample.	Date collected. Month.	Day.	Color.	Turbidity.	Sediment.	Oder.	Oxygen required.
1	12		Findlay, above town	July	21	.2	S.	S.	None	4.80
	50		" "	Aug.	25	28	None	S.	Musty	7.09
	62		" "	Sept.	26	.5	Dec.	S.	Peculiar, bad	8 78
	88		" "	Oct.	24	.45	S.	V. S.	V. disagreeable	9.24
	114		" "	Nov.	14	.32	Dec.	C.	Peculiar	11.19
			Average			.35				8.25
1a	13	3	Findlay, below town	July	21	1.00	S.	S.	Bad, oily	6.40
	49		" "	Aug.	25	.2	None	C.	Musty	4 80
	61		" "	Sept	26	.45	Dec.	S.	Peculiar, bad	7.19
	87		" "	Oct.	24	.3	Dis.	S.	Foul	4.63
	113		" "	Nov.	14	.3	Dec.	C.	Peculiar	11.54
			Average			.45				6.91

Ottawa River.

2	14		Lima, above town	July	21	.1	V. S.	V. S.	Slight musty	4.70
	40		" "	Aug.	24	.15	None	V. S.	Slight musty	3.51
	64		" "	Sept.	26	.45	Dec.	S.	None	11.77
	90		" "	Oct.	24	.45	S.	V. S.	None	7.35
	127		" "	Nov.	16	.32	Dis.	C.	Faint oily	6.59
			Average			.29				6.78
2a	15	4	Lima, below town	July	21	3.50	Dec.	M.	Foul, oily	65.87
	39		" "	Aug.	24	4.00	Dec.	M.	Foul	110.47
	63		" "	Sept.	26	.8	Dec	M.	Foul	42.72
	89		" "	Oct.	24	.....	†			
	126		" "	Nov.	16	.32	Dis.	C.	Oily	9.56
			Average			2.15				57.04

Auglaize River

4	19	*69	Defiance, above town	July	22	.2	Dis.	S.	None	5.35
	42	‡59	" "	Aug.	28	.35	S.	S.	Faint musty	6.40
	69		" "	Sept.	27	5	Dec.	S.	Woody	14.20
	95		" "	Oct.	25	.4	Dis.	S.	Musty	9.01
	120		" "	Nov.	15	.28	Dec.	C	Earthy	9.97
			Average			.35				8.97

St. Mary River.

3	17		Ft. Wayne, above town	July	22	1	None	V. S.	None	4.34
	38		" "	Aug.	28	.25	None	None	None	4.60
	67		" "	Sept.	27	4	Dis.	S.	None	10.12
	93		" "	Oct	25	.4	Dis.	V. S.	Earthy	6.88
	125		" "	Nov.	16	.26	Dec.	C.	Woody	15.04
			Average			.28				8.19

*From Station 1. ‡From Station 2. †Sample lost by breaking of bottle during transportation.

MAUMEE WATERSHED.

Blanchard River.

(Parts per million.)

Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen—Per cent. saturation.	Bacteria per C. C.	Temperature ° C.
Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
0.198	0.033	.008	0.382	19.5	180.2	154 6	678	156	79.0	292	28.
0.281	0.332	.035	18 400	165.5	* 50 6	162.1	1,222	315	59 0	1,110	26.
0.338	0.294	.200	6 330	449 5	67 9	125.2	1 258	3s0	61.4	980	20.5
0.258	0 136	.018	8.280	114.5	138.0	98 6	725	203	78.8	1,486	8.5
0 408	0.080	.020	14.185	44.9	128.6	72 0	529	257	80.4	1,285	6.
0.297	**0.175**	**.056**	**9.505**	**164.8**	**82.8**	**122.5**	**882**	**262**	**71.7**	**1,011**	.....
0.630	0.182	†	0 327	107.7	188.4	147.2	830	263	159.0	7,790	28.
0.292	0.344	.060	15 500	127.8	* 44 0	156.1	962	153	56.2	3,370	27 5
0 412	0.584	.238	3,563	350.9	70.1	111.4	1,802	394	53.8	34,960	20.5
0.300	0 406	.090	9 200	266 0	91.4	125 6	1,078	36	78.2	18,050	11.
0 464	0.100	.021	13 042	84.0	128.8	58 6	586	235	69 6	1.900	6.
0.420	**0 319**	**.102**	**8.384**	**177.2**	**94.9**	**119.8**	**941**	**281**	**82.4**	**12,214**	.....

Ottawa River.

0.154	0.027	None.	0 318	29.6	187 2	158.0	642	170	102.0	497	29.
0.199	0 055	None.	0 220	24.3	173.8	74.6	590	77	88.3	895	28.
0 250	0.054	.005	0. 36	119 8	151.6	78.2	828	232	58.7	3,4 0	22.
0.198	0 018	.010	0.345	22.1	172.2	30.4	392	141	99.8	2,910	11.5
0 240	0 058	.010	10.434	17.1	137 8	57.6	373	132	87.9	1,130	5.
0.208	**0 042**	**.005**	**2.291**	**42 6**	**164.5**	**79.8**	**565**	**150**	**87.3**	**1,776**	.....
1.068	0.081	†	0.55	83.2	227.6	171.4	1,265	462	0.0	371 300	31 2
1 072	0 690		2.49	195.7	383 0	94.4	1.121	523	0.0	227.80.0	25.5
0 844	0 161		0.557	300.2	257 6	61.3	1,224	373	27.5	94,8 0	22.5
.....	.....	.....	.....	.....	.....	.....	...	.....	68.6	76, 60	11.5
0.180	0.29	.042	10.018	35.0	140.0	57.4	457	168	82.7	15 760	5.
0 866	**0 285**	**.042**	**3 403**	**178.8**	**247 0**	**96 1**	**1.017**	**382**	**35 6**	**157,248**	.....

Auglaize River.

0.281	0.035	None.	0.276	106 6	142.8	86.4	455	116	104.0	615	30.
0.256	0.101	.025	1.660	95 0	126.0	37.0	580	141	107.7	485	28.
0.304	0.060	.008	2.621	117.1	128 9	72 4	870	284	64.6	8,500	21.
0.256	0 029	Trace	0 436	71 4	158 2	61 6	602	174	85 0	6,070	11.
0.372	0.116	008	9.001	27.8	139.0	48 4	885	132	88 6	10,0 0	5.5
0.295	**0 068**	**.008**	**2 798**	**83 6**	**139 0**	**60.2**	**578**	**159**	**90.0**	**4,150**	.....

St. Mary River.

0.241	0.029	None.	0.444	34.5	160.2	100.8	885	269	85.0	665	27.5
0.216	0.075	None.	0.072	104 5	141.2	68 8	716	145	98.2	1,560	29.
0 308	0 184	.005	0.093	76 6	155 9	44.4	589	159	79.5	1,550	21.
0.276	0.038	.004	0.181	96.4	148 2	94.6	580	160	90 9	1,317	11.
0.432	0.044	.008	9.473	34 5	109 6	29.4	420	147	81.4	7,360	3.5
0 295	**0.064**	**.003**	**2 052**	**69.3**	**143.0**	**67 6**	**628**	**176**	**87 0**	**2,488**	.....

* Acid † Reaction interfered with.

MAUMEE WATERSHED—Continued.

St. Joseph River.

(Parts per million.)

Station.	Sample number.	Approximate distances.	Location of sample.	Date collected. Month.	Day.	Color.	Turbidity.	Sediment.	Odor.	Oxygen required.
3a	37	.....	Ft. Wayne, above town	Aug.	23	.25	V. S.	V. S	None	4.95
	66		" "	Sept.	27	.25	V. S.	V. S.	None	3.74
	92		" "	Oct.	25	.55	Dis.	S.	Woody	14.69
	123		" "	Nov.	16	.4	Dec.	C.	Woody	18.20
			Average			.36				10.40

Maumee River.

2a	16	From 3, to 5 5	Ft. Wayne, below town	July	22	2	S.	S.	Foul	5.07
	38		" "	Aug.	23	.3	S.	S.	Sewage	5.82
	65	From 3 to 3.5	" "	Sept.	27	.4	S.	C.	Sewage	6.35
	91		" "	Oct.	25	.6	Dis.	S.	Faint sour	14.43
	124	.....	" "	Nov.	16	.88	Dec	C.	Peculiar earthy	15.78
		.....	Average			.33				9.40
4a	18	60	Defiance, above town	July	22	.1	V. S	V. S	None	4.80
	41		" "	Aug.	24	.25	V. S	V. S.	None	5.45
	68		" "	Sept.	27	.4	S.	S.	None	7.42
	94		" "	Oct.	25	.42	V. S.	S.	Faint woody	13.50
	122		" "	Nov.	15	.3	Dec.	C.	Earthy	16.17
			Average			.3				9.37
4a	20	31-62	Defiance, below town	July	22	.2	Dis.	S.	Faint offensive	5.80
	43	1-70	" "	Aug.	24	.35	S.	S.	Slight musty	7.27
	70	2-60	" "	Sept.	27	.5	S.	S.	Musty	7.33
	96		" "	Oct.	25	.4	S.	S.	Earthy	13.55
	121		" "	Nov.	15	.32	Dec.	C.	Earthy	11.26
			Average			.35				8.84
5	21	31-78	Napoleon, above town	July	28	.2	Dis.	V. S.	None	5.38
	44	1-86	" "	Aug	25	.3	S.	V. S.	None	5.56
	71	2-76	" "	Sept.	28	.35	S.	S.	None	6.11
	97		" "	Oct.	26	.4	Dis.	S.	Earthy	12.66
	118		" "	Nov.	15	.32	Dec.	C.	Earthy	18.61
			Average			.31				9.66
5a	22	31-80	Napoleon, below town	July	23	.2	Dis.	S.	Slight sour	5.85
	45	1-88	" "	Aug.	25	.33	S.	V. S.	None	6.58
	72	2-78	" "	Sept.	28	.35	S.	S.	Faint musty	6.12
	98		" "	Oct.	26	.4	Dis.	S.	Faint musty	13.94
	119		" "	Nov.	15	.32	Dec.	C.	Earthy	14.89
			Average			.32				9.48
6	23	31-116	Toledo, above town	July	23	.1	Dis.	S.	None	5.92
	48	1-124	" "	Aug.	25	.25	V. S.	V. S.	None	5.75
	75	2-114	" "	Sept.	27	.4	V. S.	S.	None	7.23
	100		" "	Oct.	26	.42	Dis.	S.	Faint musty	9.45
	117		" "	Nov.	14	.3	Dec.	C.	Earthy	15.96
			Average			.29				8.69

MAUMEE WATERSHED—Continued.

St. Joseph River.

(Parts per million.)

Nitrogen as											
Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen—Per cent. saturation.	Bacteria per C. C.	Temperature ° C.
0.186	0.070	None.	0.116	4.7	219.0	10.4	362	19	99 5	1,260	27.
0.182	0.056	None	0.078	2.2	232.2	0.	335	85	94.9	1,400	22.
0.410	0.046	.008	0.264	5.0	172.0	67.8	433	127	81.9	818	10.
0.392	0 028	.005	7.611	2.5	122 2	31 0	375	153	86.9	5,860	3.
0.278	0.050	.003	2.017	3.6	186 4	27.3	376	96	90.8	2.333	....

Maumee River.

0.271	0.262	.015	0.333	189.0	229 0	101.2	507	182	86 0	145,400	27.
0.356	0.596	.042	0.164	45.2	191.8	41.8	475	81	40.9	39,040	28. 5
0.376	0.248	.018	0 371	20.9	219 0	38 8	421	111	54 8	37,510	19.
0.512	0 1·8	020	0.420	31.8	170.2	55.0	470	144	66.1	7,040	10.
0 448	0 060	.010	8.750	15 5	123.2	22.4	378	171	75.8	20,280	3.5
0 393	0 267	.019	2.008	50 5	186.6	51.8	449	128	54 6	49,814	.....
0.185	0.058	None.	0.414	24.5	157.2	69.0	415	140	102 0	329	29.5
0 ·06	0 042	None.	0.188	14.9	144.6	4.2	364	54	91.8	838	29.5
0.260	0.044	.008	0.179	17.7	174.3	12.1	441	186	88.0	1,310	21.
0.418	0.070	.005	0.384	25.2	150.6	45.0	498	169	81.8	1,143	11.
0.488	0.064	.005	10.671	13.6	113.3	41.0	393	155	85.7	18,300	5.
0.331	0 055	.004	2 363	19 2	148.0	34 3	422	131	88 9	4,384	.....
0 864	0.067	Trace.	0.400	42.1	160.4	75 8	620	201	99.0	723	30.
0.460	0.168	.015	0.284	51.7	150.2	12.6	431	87	88.1	6,900	28.
0.380	0.076	.008	0.197	30 8	173 8	0.	381	116	83.9	5,720	21.
0.372	0.080	.015	1.140	77.2	159 6	40.4	568	170	79.7	7,540	11.
0 3.0	0.080	.010	9.671	26 7	140.7	38 8	410	165	79.0	22,040	5.
0 379	0.(94	.010	2.338	46.5	156.9	33 5	482	138	85.9	8,585	.....
0.288	0.094	Trace.	0.454	29.5	146.8	20.0	390	106	80.0	569	27.
0 263	0.058	Trace.	0.322	64.3	137.2	31.2	439	47	92.3	210	26.5
0.210	0.054	Trace.	0.225	104.6	144.6	12 2	486	115	70 5	575	18.
0.266	0.042	.005	0.260	36.1	156 4	41.0	399	130	79.3	5,450	9.5
0.316	0.040	.006	10.250	8.1	118 2	24.2	395	125	85.5	7,710	3.
0 269	0 058	.002	2.302	48.5	140.6	25.7	422	105	81.5	2,903	.....
0.297	0.115	.002	0.418	32.7	152.6	47.3	436	116	75.0	992	27.5
0.360	0.094	.001	0.356	66.0	139.8	14 8	480	68	96.6	4,315	26.
0.368	0.072	.002	0.246	81.1	153.8	32.0	573	181	77.8	1,100	19.5
0.312	0.092	.008	0.284	37.2	168.2	43 6	474	152	79.1	26,520	10.
0.656	0.068	.007	10.041	12.2	112.8	26.6	421	133	74.8	16,400	3.
0.379	0.088	.004	2.269	45.8	145.4	32.9	477	130	80.7	9,865	....
0.262	0.088	.015	0.254	29.2	156.6	40.2	365	96	83.0	* 270	28.
0.332	0.068	Trace.	0 272	50.2	150.2	5.0	434	15	78.6	* 250	26.
0.276	0.022	None.	0.185	60.2	154.9	20.4	515	170	94.1	195	21.
0.328	0.028	.010	0.168	34.4	142.4	31.0	462	143	80.3	1,342	11.
0.504	0.146	.008	8.274	21.1	122.4	13.6	439	99	91.3	7.360	5.5
0.338	0 070	.007	1.821	39.0	145.3	22.0	443	105	85.5	1,883	.....

* Count low owing to interference from overspreading growth

MAUMEE WATERSHED—Concluded.

MAUMEE RIVER—Concluded.

(Parts per million.)

Station.	Sample number.	Approximate distances.	Location of sample.	Date collected. Month.	Day.	Color.	Turbidity.	Sediment.	Odor.	Oxygen required.
6a	24	81-119	Toledo, Cherry St. bridge	July	23	.1	Dis.	S.	Offensive	5.94
	47	1-127	" "	Aug.	25	.28	V. S.	S.	Musty	6.36
	73	2-117	" "	Sept.	27	.42	V. S.	S.	Faint sour	10.05
	99		" "	Oct.	26	.4	Dis	S.	Musty	7.96
	116		" "	Nov.	14	.3	Dec.	C.	Earthy	18.01
			Average			.30				9.62
6b	25	81-120	Toledo, Riverside Park	July	23	.1	Dis.	S.	Offensive	5.85
	46	1-128	" "	Aug.	25	.3	V. S.	S.	Musty	7.01
	74	2-118	" "	Sept.	27	.45	V. S.	S.	Faint sour	9.99
	101		" "	Oct.	26	.4	Dis.	S.	Musty	8.56
	115		" "	Nov.	14	.3	Dec.	C.	E'thy, f't oily	18.17
			Average			.31				9.92

MAUMEE WATERSHED—Concluded.

MAUMEE RIVER—Concluded.

(Parts per million.)

Nitrogen as											
Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen—Per cent. saturation.	Bacteria per C. C.	Temperature ° C.
0.332	0.168	.080	0.364	29.4	164.2	65.8	372	98	47.0	1,030	28.
0.340	0.244	.015	0.336	44.5	143.6	9.2	481	111	46.3	5,310	26.
0.420	0.208	.009	0.45	63.6	161.5	19.5	491	168	57.6	4,275	21.
0.308	0.151	.011	0.392	63.8	141.6	32.8	456	14	65.4	4,250	10.
0.504	0.104	.009	8.140	32.8	130.2	28.0	432	131	82.1	19,160	5.
0.381	0.156	.015	1.867	46.7	148.2	31.1	446	130	59.7	6,805	.....
0.286	0.109	.035	0.368	26.6	157.0	46.1	388	58	78.0	576	28.
0.356	0.280	.021	0.300	40.6	148.4	18.0	502	142	54.4	* 220	26.
0.348	0.248	.019	0.152	63.3	158.8	28.6	449	150	56.1	4,870	21.
0.332	0.104	.011	0.256	64.3	140.0	30.6	524	148	83.4	13,600	10.
0.476	0.096	.010	8.581	28.1	128.4	32.0	473	147	77.9	16,100	5.
0.360	0.167	.019	1.931	44.6	146.5	30.1	457	128	70.0	6,973	.....

* Count low owing to interference from overspreading growth.

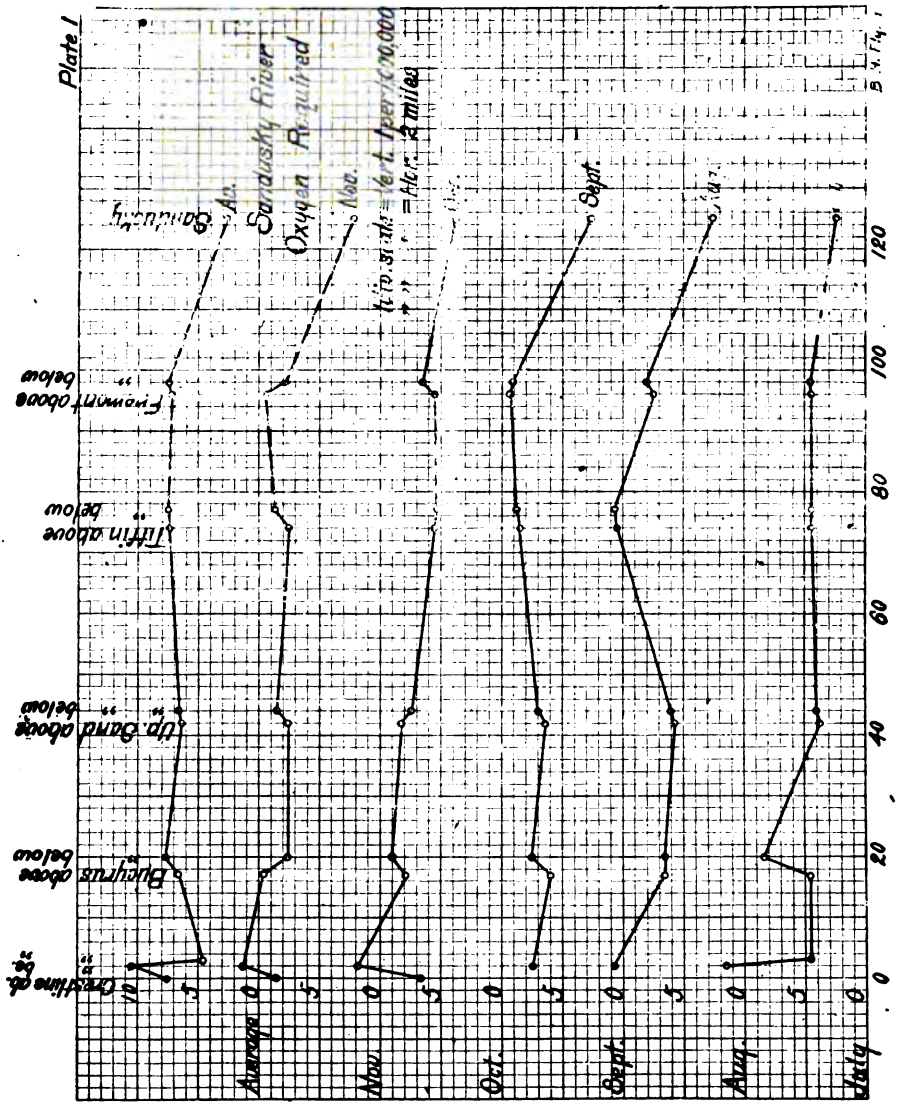
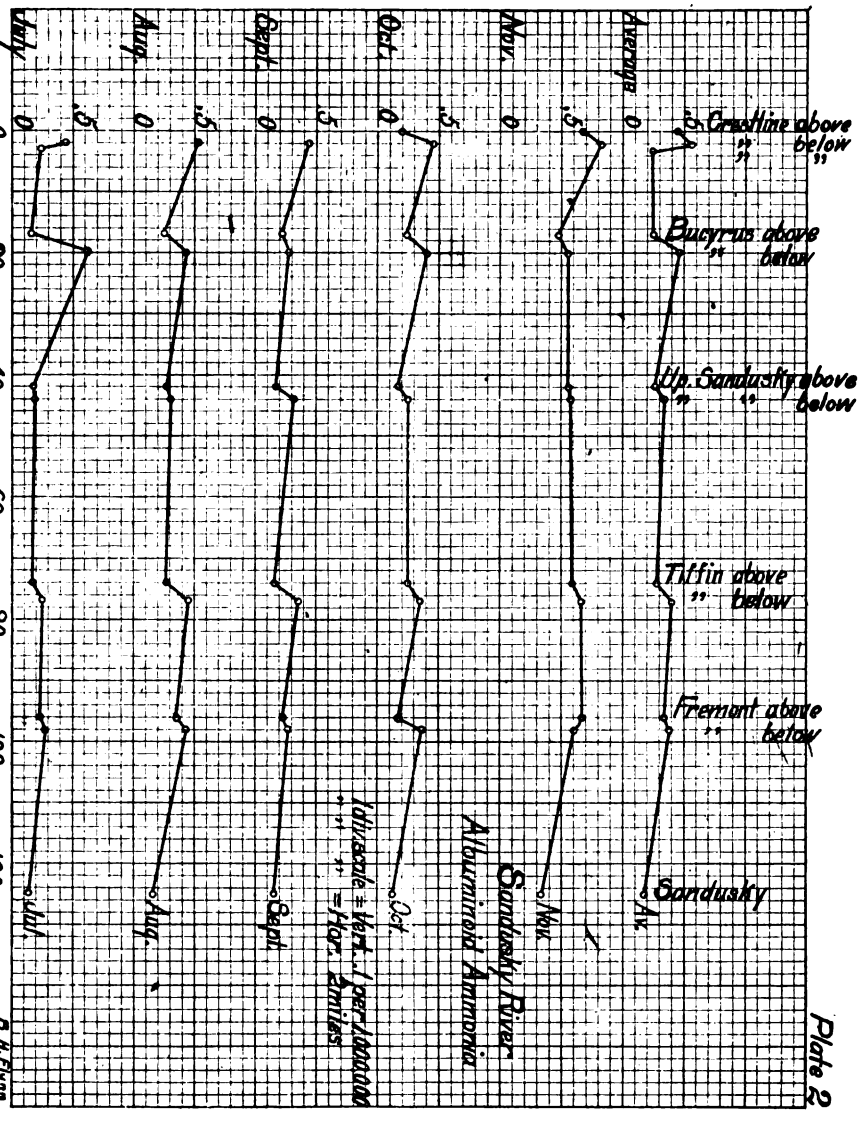


Plate I
Sandusky River
Oxygen Required
Aug.
Sept.
Oct.
Nov.
Average
July
Aug.
Sept.
Oct.
Nov.
Average
Creek line about
Dupont above
Dupont above
Up. Canal above
Fremont above
Fremont above
Tiffin above
Tiffin below
Up. Canal above
Up. Canal below
Dupont above
Dupont below
Creek line about
Fremont above
Fremont below


July
Aug.
Sept.
Oct.
Nov.
Average
0
.5
Crestline above
" below
Bucyrus above
" below
Up. Sandusky above
" below
Tiffin above
" below
Fremont above
" below
Sandusky
Av.
Nov.
Oct.
Sept.
Aug.
July
0
20
40
60
80
100
120
Sandusky River
Albuminoid Ammonia
Latitude scale = Vert. 1 per 1000 ft
+ + + + = Hor. 2 miles
B. H. Flynn
Plate 2

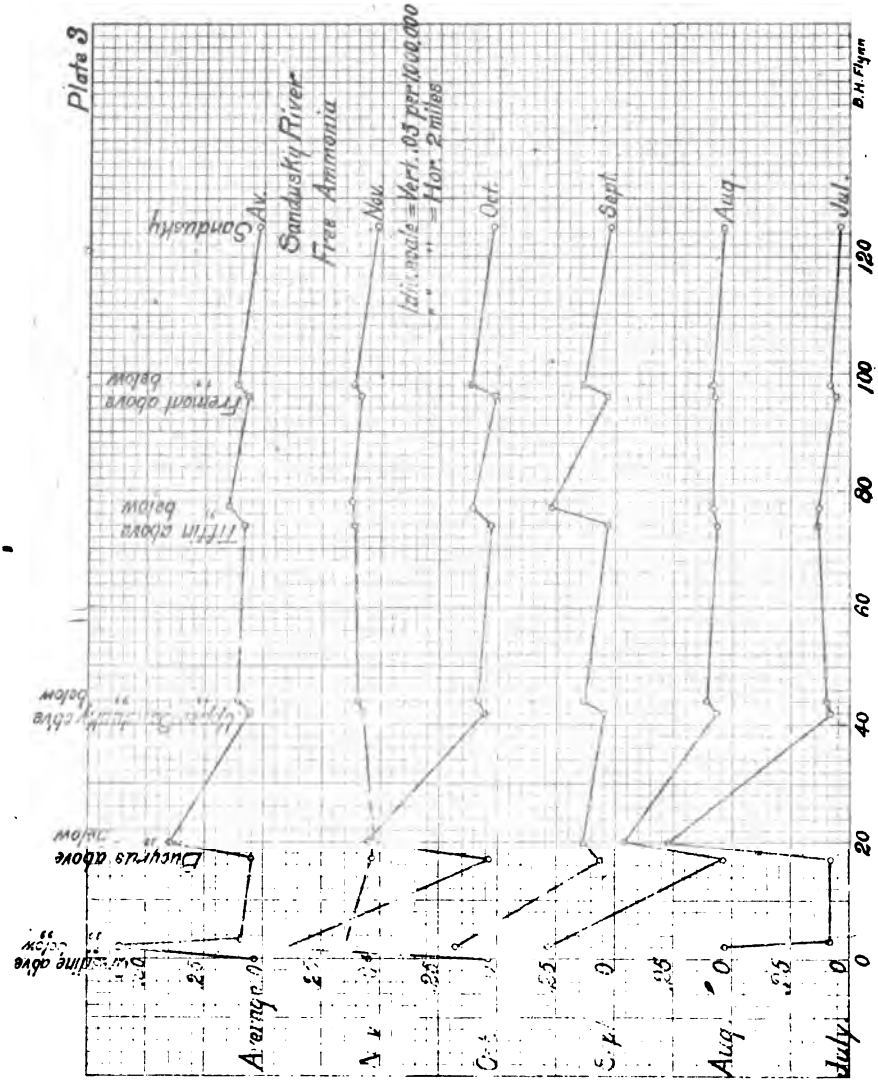
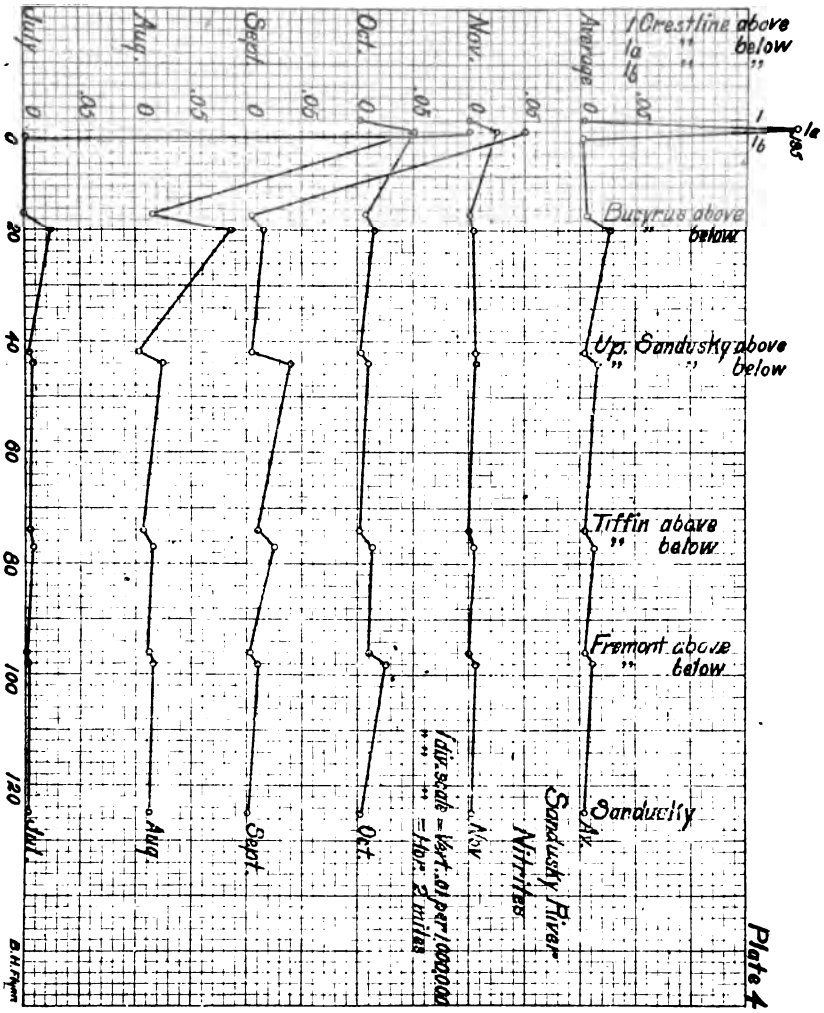


Plate 3
Sandusky River
Free Ammonia
Vertical scale = Vert. .05 per 1000,000
" " = Hor. 2 miles
Sandusky Av.
Nov.
Oct.
Sept.
Aug.
July
B.H. Flynn
Fremont above
" below
Tiffin above
" below
Upper Sandusky above
" below
Ducharus above
" below
Wauseon above
" below
Average
Nov.
Oct.
Sept.
Aug.
July
0
20
40
60
80
100
120


July
Aug.
Sept.
Oct.
Nov.
Average
1 Crestline above
1a " below
1b " "
Bucyrus above
" below
Up. Sandusky above
" " below
Tiffin above
" below
Fremont above
" below
Sandusky
Sandusky River
Nitrites
Vert. scale = Vert. .01 per 1,000,000
" " " = Hor. 2 miles
Plate 4

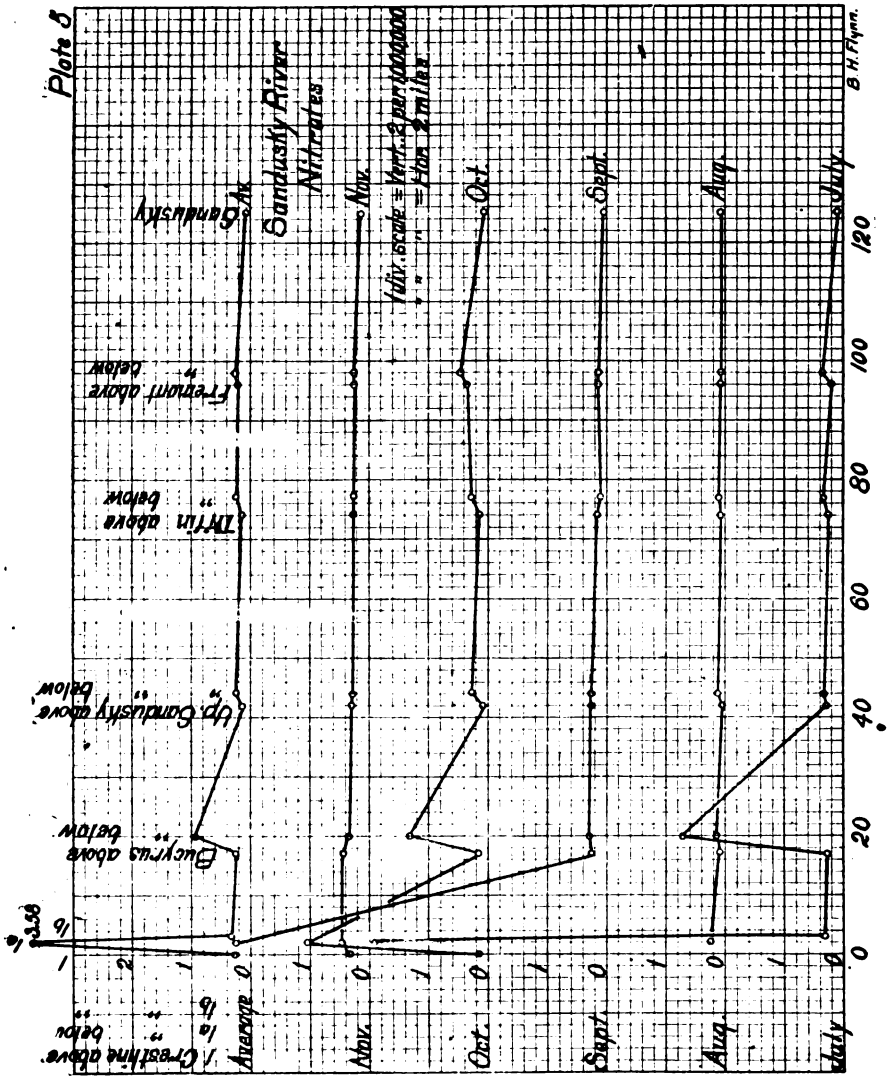
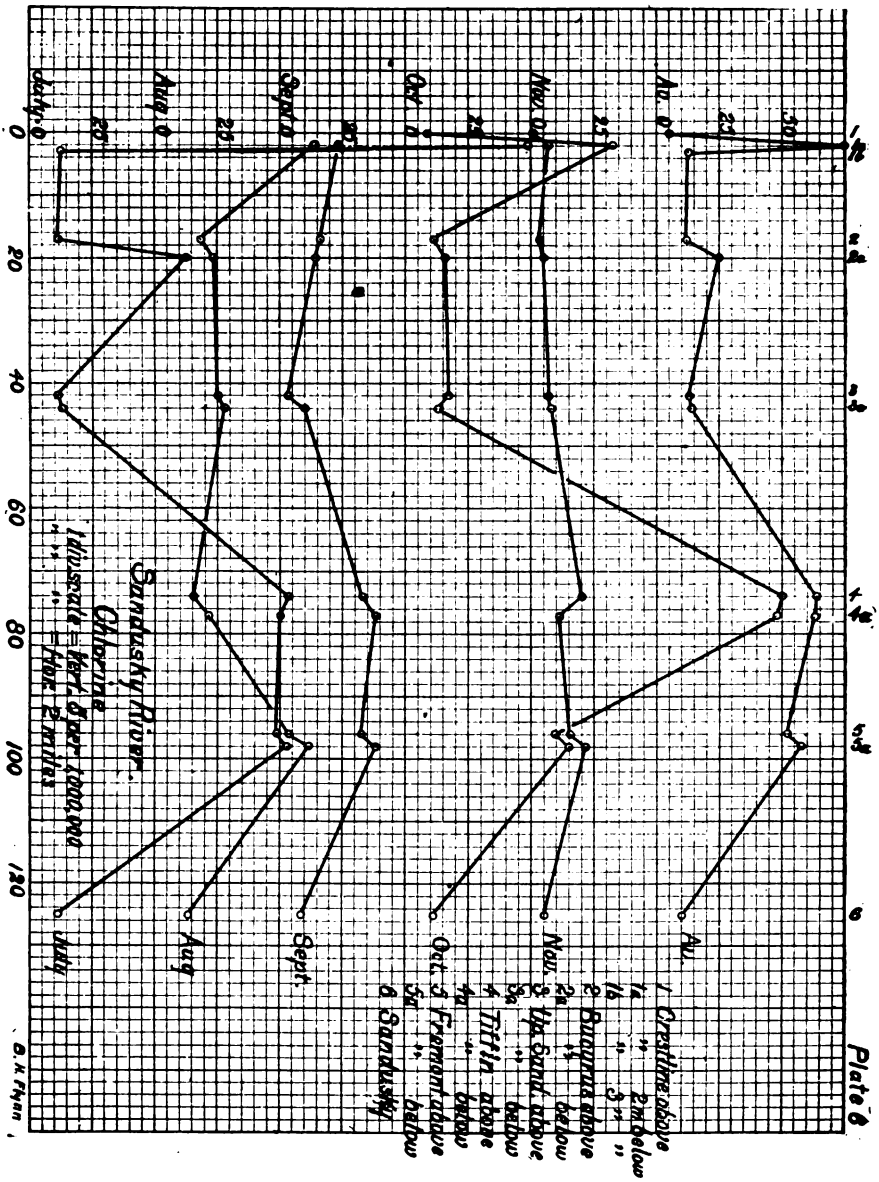


Plate 5
Sandusky River
Nitrates.
B. H. Flynn.
Vert. scale = Vert. 2 parts/1000
" " = Hor. 2 miles
Sandusky
Ak
Nov.
Oct.
Sept.
Aug.
July
Fremont above
" below
TIffin above
" below
Up. Sandusky above
" below
Ducyrus above
" below
Crestline above
" below
Average
Nov.
Oct.
Sept.
Aug.
July
0
20
40
60
80
100
120
1
2
1
0
1
0
1
0
1
0
1
0
lb
lb
lb
lb


Sandusky River.
Chlorine
1 illustrate = Part of per 100,000
" " = Part 2 nitrates
Aug. 0
Sept. 0
Oct. 0
Nov. 0
Aug.
Sept.
Oct.
Nov.
Aug.
1 Crestline above
2m below
1a " 2m "
1b " 3 "
2 Bucyrus above
2a " below
2b " above
3a " below
3 Tiffin above
4a " below
4 Fremont above
5a " below
5 Sandusky
Plate 6

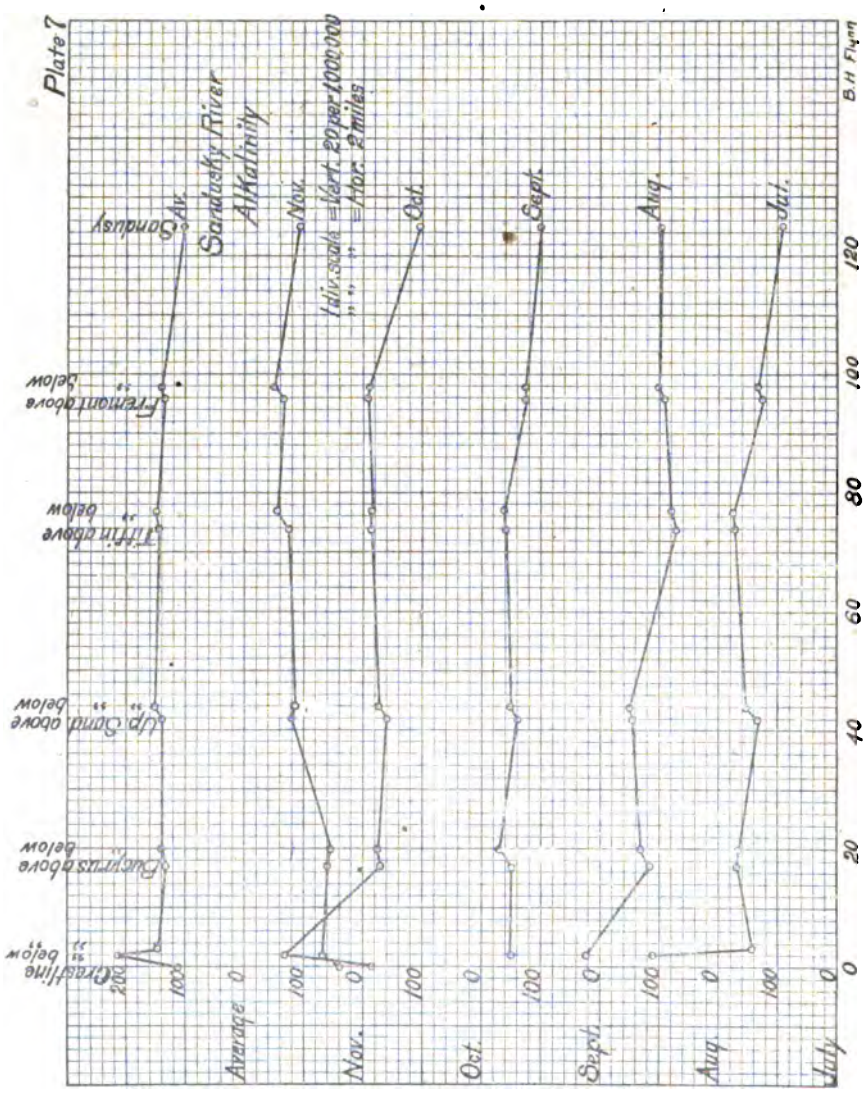
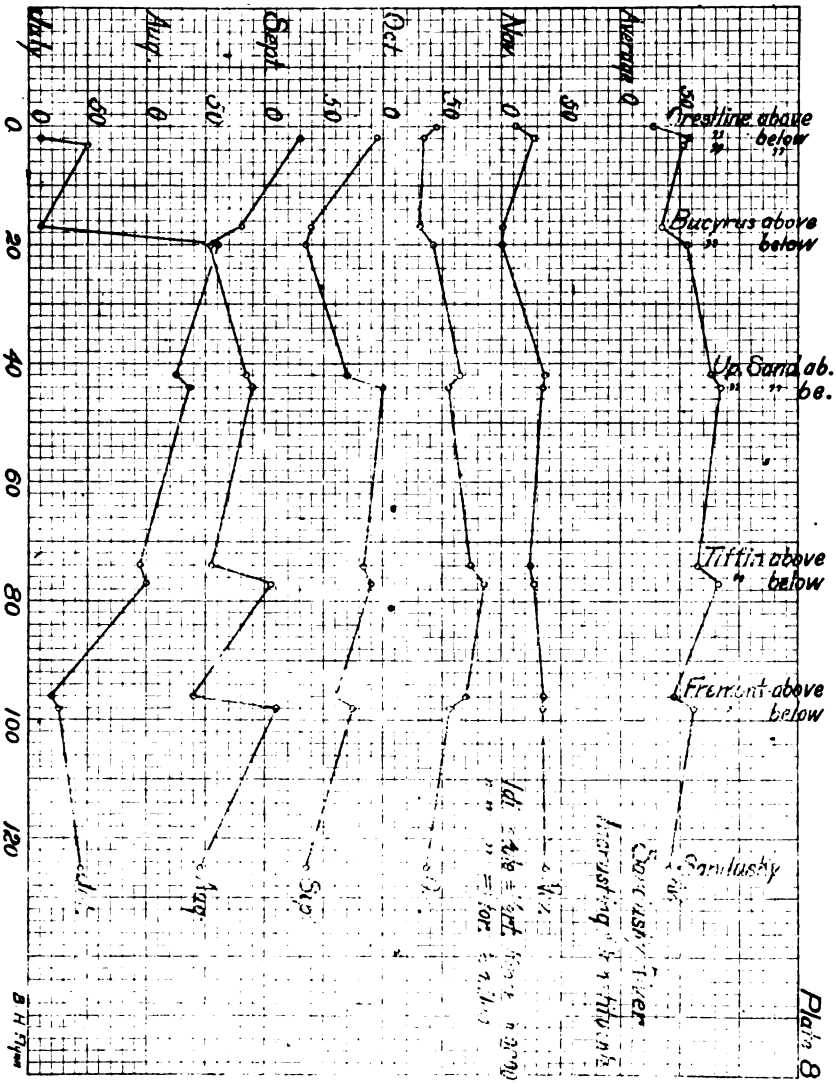


Plate 7
Sandusky River
Alkalinity
Nov.
Oct.
Sept.
Aug.
July
Av. Sandusky
Fremont above
" below
Tiffin above
" below
Upper Sand. above
" below
Decatur as above
below
Greenline
" below
Average
Nov.
Oct.
Sept.
Aug.
July
B.H. Flum
0
20
40
60
80
100
120
100
0


July
Aug.
Sept.
Oct.
Nov.
Average
0
20
40
60
80
100
120
Crestline above
" below
Bucyrus above
" below
Up. Sand ab.
" " be.
Tiffin above
" below
Fremont above
below
Sandusky
Plate 8

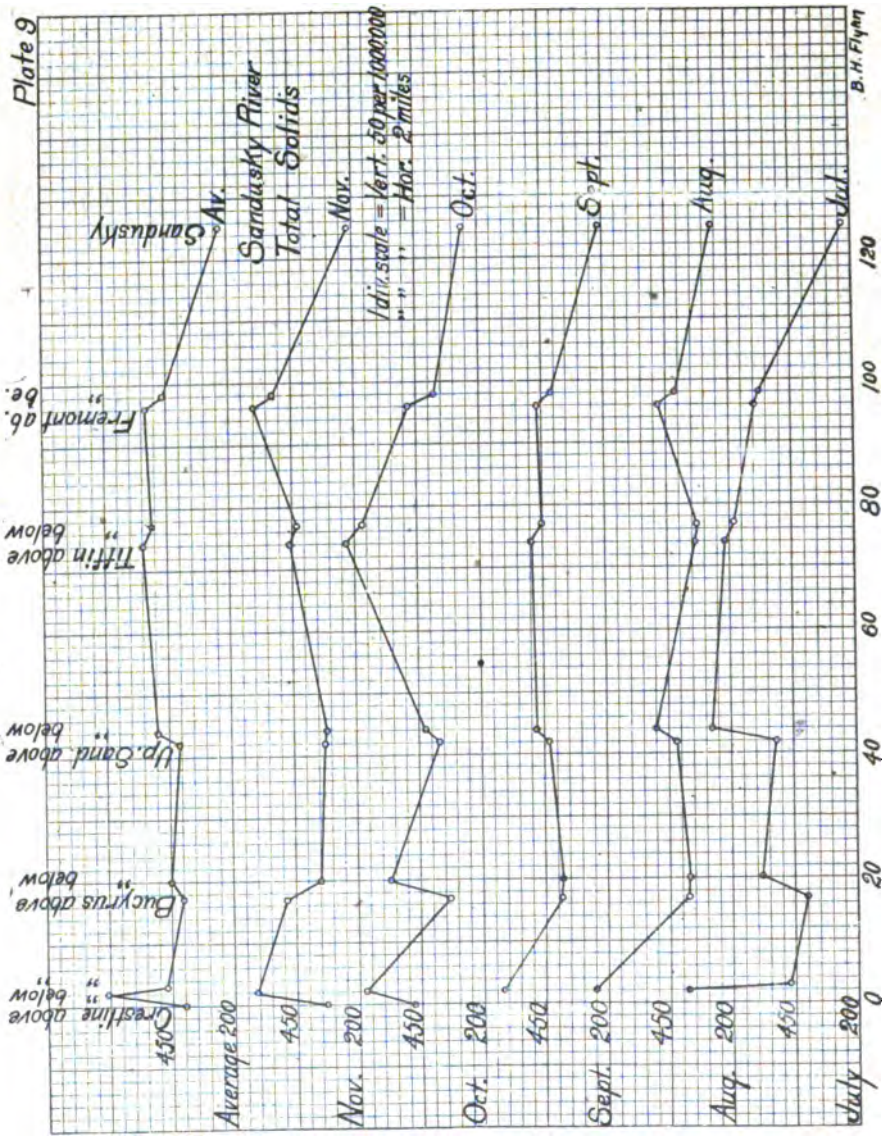
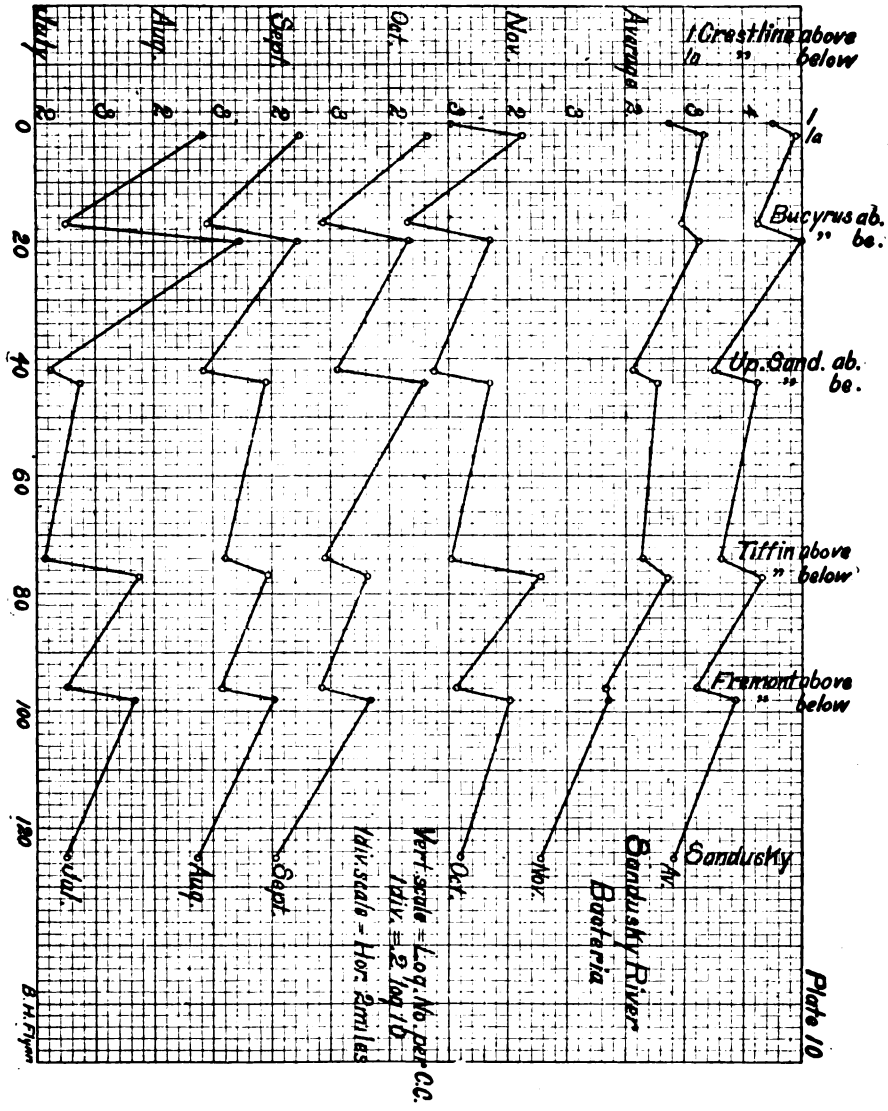


Plate 9
Sandusky River
Total Solids
Vert. scale = Vert. 50 per 1000000
" " " = Hor. 2 miles
B. H. Flynn
Av. Sandusky
Fremont ab. be.
Tiffin above below
Up. Sand. above below
Bucyrus above below
Crestline above below
Average 200 450
Nov. 200 450
Oct. 200 450
Sept. 200 450
Aug. 200 450
July 200
Nov.
Oct.
Sept.
Aug.
July
0 20 40 60 80 100 120


July
Aug.
Sept.
Oct.
Nov.
Average
1 Crestline above
1a " below
1
1a
Bucyrus ab.
" be.
Up. Sand. ab.
" be.
Tiffin above
" below
Fremont above
" below
Sandusky
Av.
Sandusky River
Bacteria
Nov.
Oct.
Sept.
Aug.
July
Vert. scale = Log. No. per C.C.
1 div. = 2 log 10
Hor. scale = Hor. 2 miles
0
20
40
60
80
100
120
Plate 10
B. H. Flynn

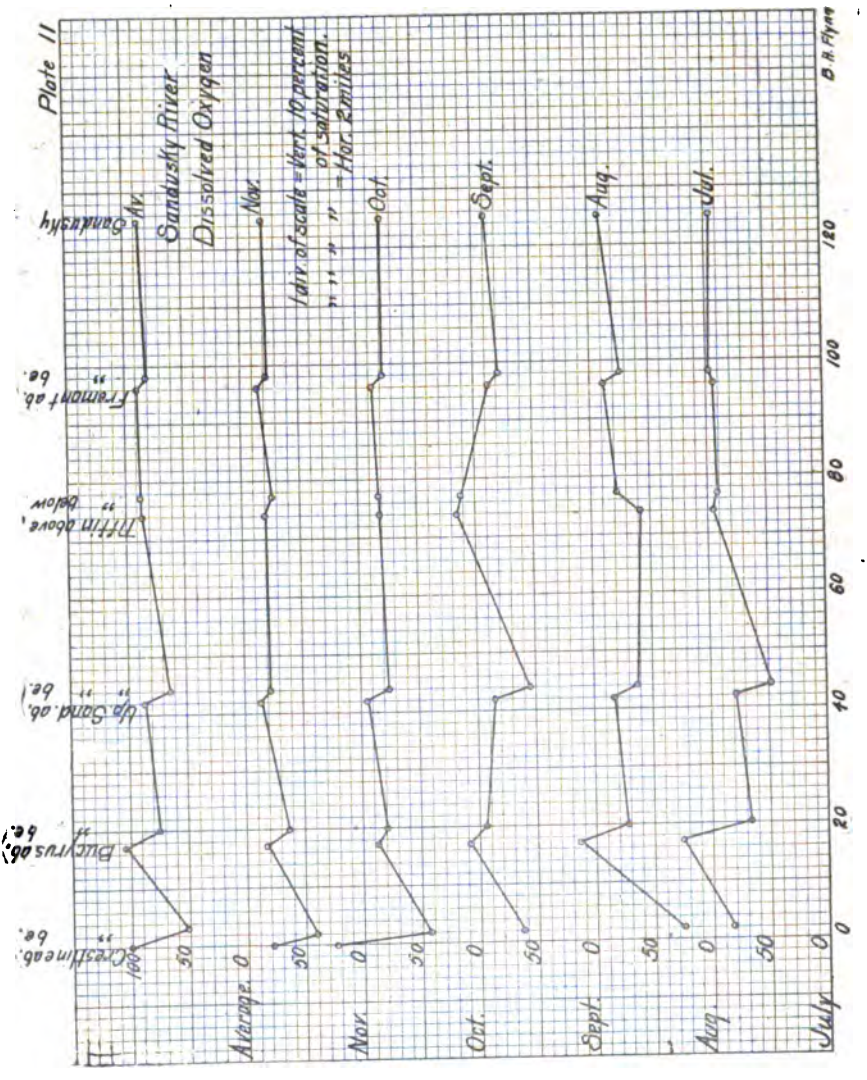


Plate II
Sandusky River
Dissolved Oxygen
Nov.
Oct.
Sept.
Aug.
July
Av. Sandusky
Fremont ab.
Tiffin above
" below
Ua. Sand. ab.
Bucyrus ab.
Crestline ab.
Average
Nov.
Oct.
Sept.
Aug.
July
B. R. Flynn

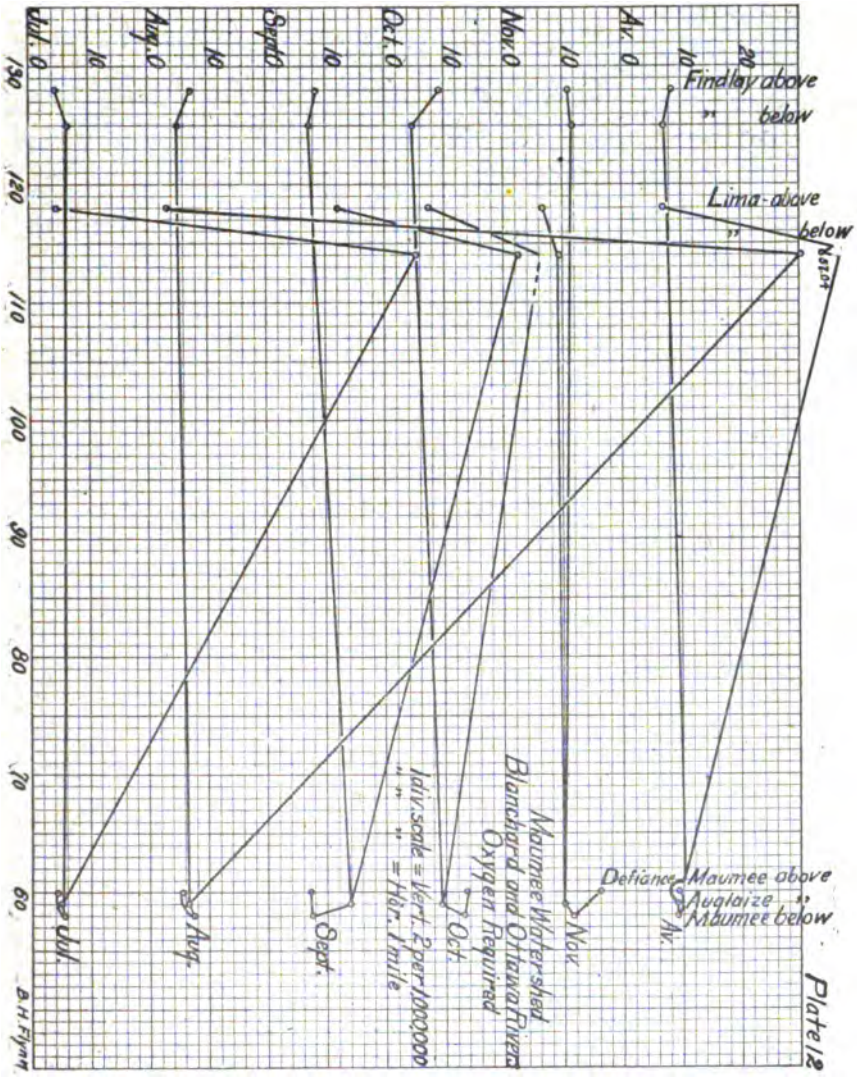
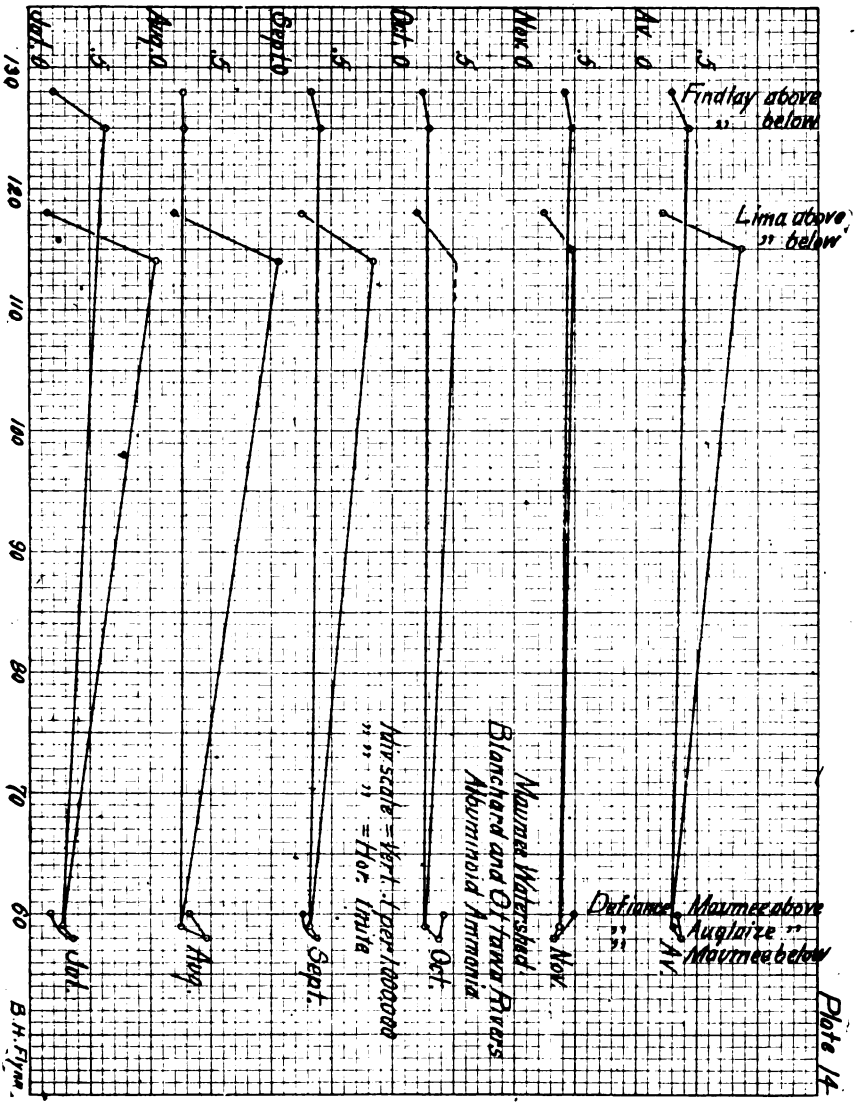

Findlay above
" below
Lima above
" below
Sept.
Defiance
Maumee above
Auglaize "
Maumee below
Maumee Watershed
Blanchard and Ottawa Rivers
Oxygen Required
July scale = Vert. 1 per 1000000
" " = Hor. 1 mile
Plate 12
D. H. Flynn

Plate 13
Maumee Waters
Oxygen Required
Nov.
Oct.
Sept.
Aug.
July
Ft. Wayne & Jeffersonville R.R. Bridge
Napoleon above
Defiance Maumee above
Napoleon below
Defiance Maumee below
Average
Nov.
Oct.
Sept.
Aug.
July


Findlay above
" below
Lima above
" below
Maumee Watershed
Blanchard and Ottawa Rivers
Albuminoid Ammonia
Air scale = Vert. Lines
" " = Hor. Units
Oct.
Nov.
Dec.
Maumee above
Auglaize "
Maumee below
Sept.
Aug.
Jul.
Plate 14
B. H. Flynn.

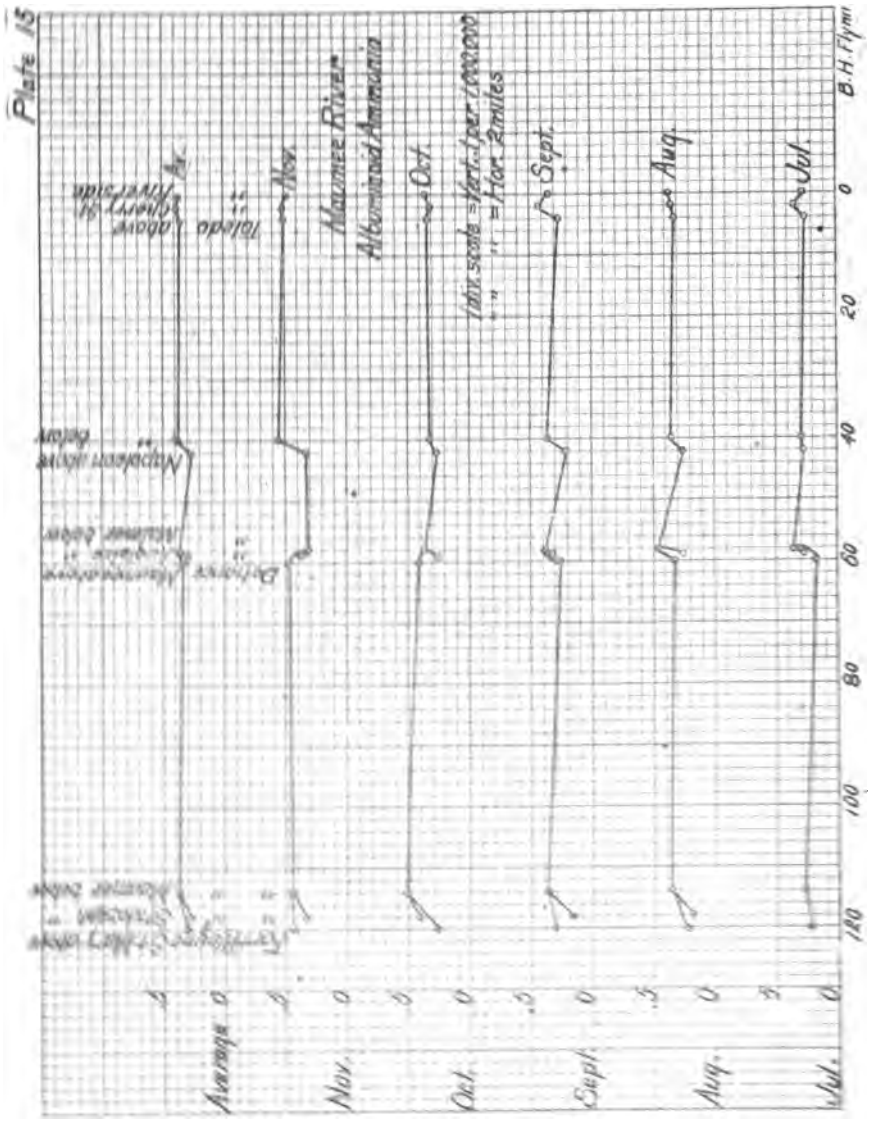
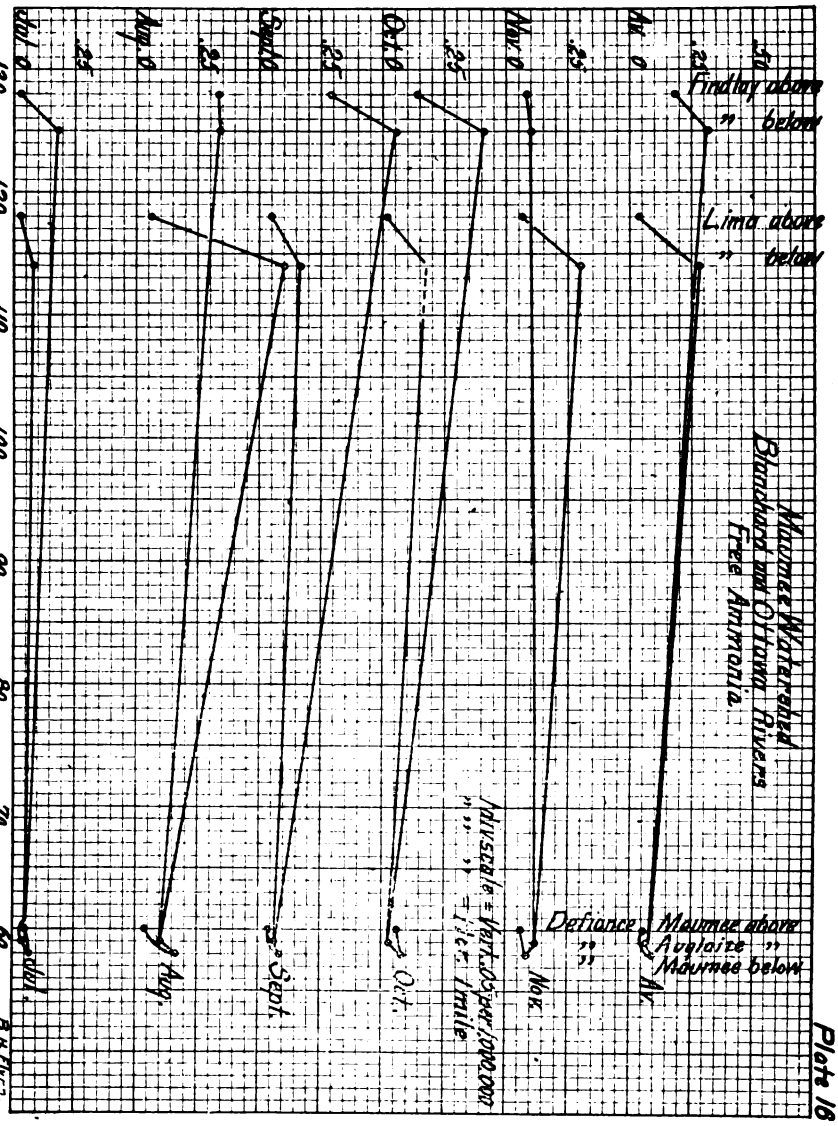


Plate 15
Average
Nov.
Oct.
Sept.
Aug.
Jul.
Sept.
Aug.
Jul.
Oct.
Mauvaises Rivers
Nov.
Toledo
Above Quarry at River side
Nov.
B.H. Flymn


Maumee Waters valued
Blanchard and Ottawa Rivers
Free Ammonia
Findlay above
" below
Lima above
" below
Defiance
" "
Maumee above
Avalaise "
Maumee below
Apr. 0
May 0
June 0
July 0
Aug. 0
Sept. 0
Oct. 0
Nov. 0
Dec. 0
Aug.
Sept.
Oct.
Nov.
Dec.
Plate 16

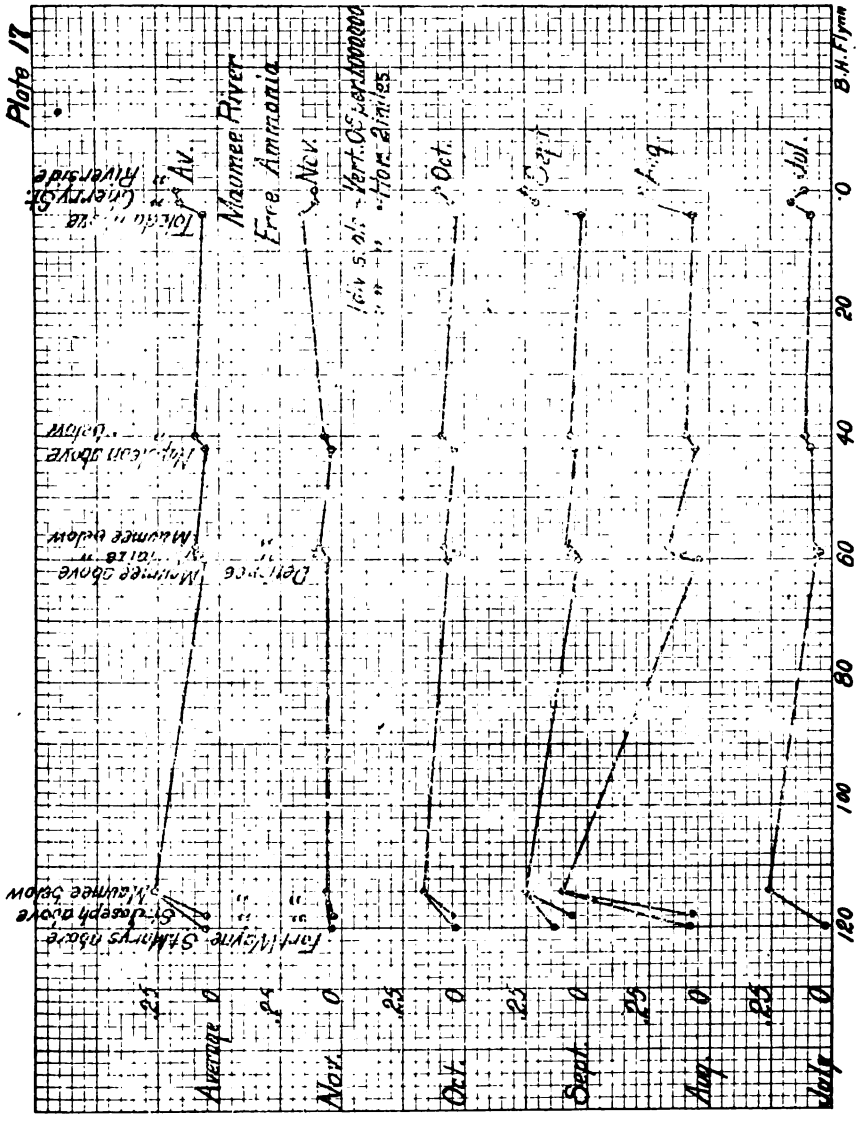
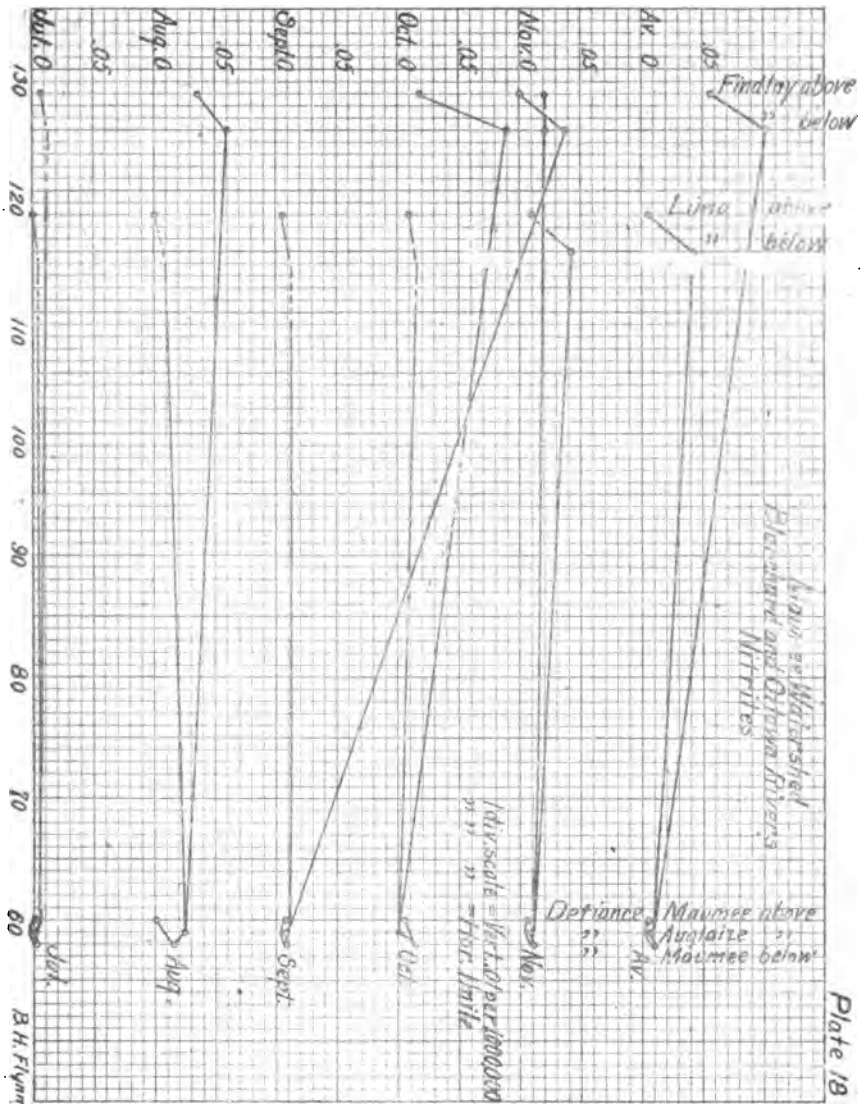


Plate 17
Miamee River
Erie, Ammania
Nov.
Vert. Oscillations from 2 inches
Oct.
Sept.
Aug.
July
B.H. Flyms
0
20
40
60
80
100
120
Average
Nov.
Oct.
Sept.
Aug.
July
25
0


Findlay above
" below
Lima above
" below
Defiance
" Maumee above
Auglaize "
Maumee below
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.

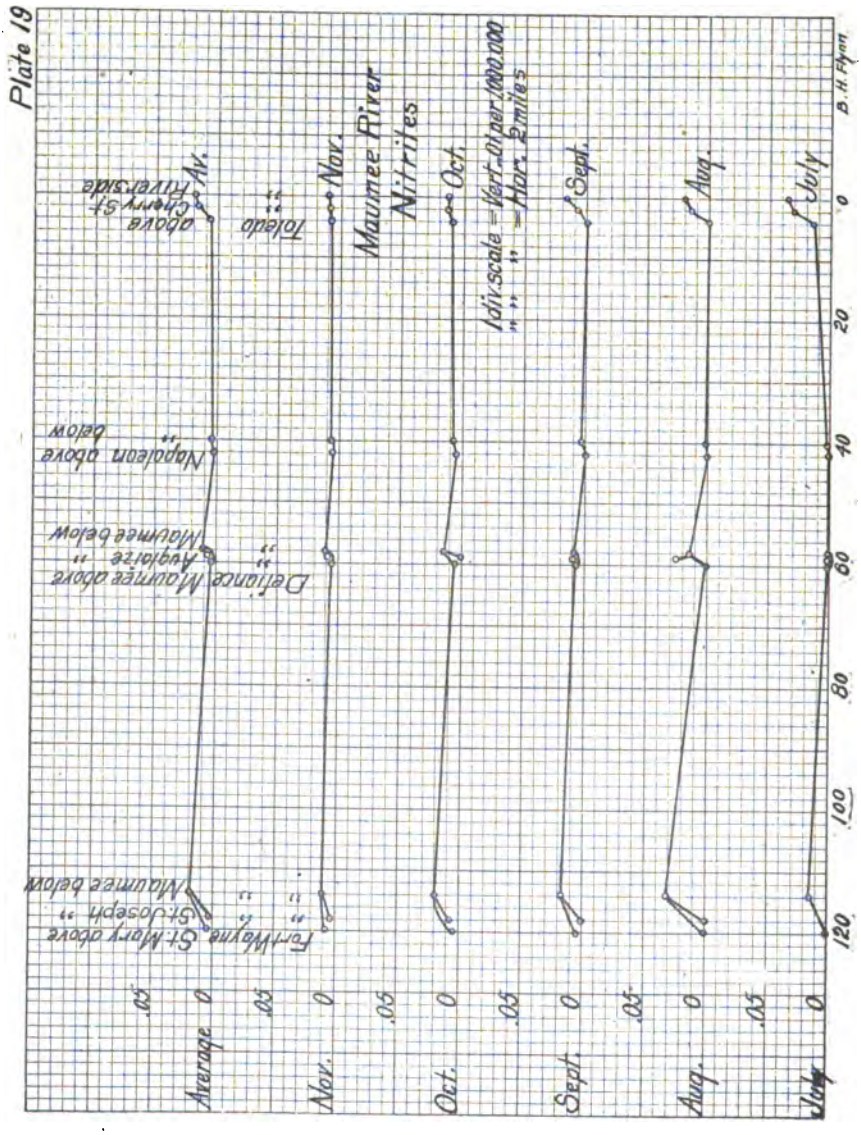
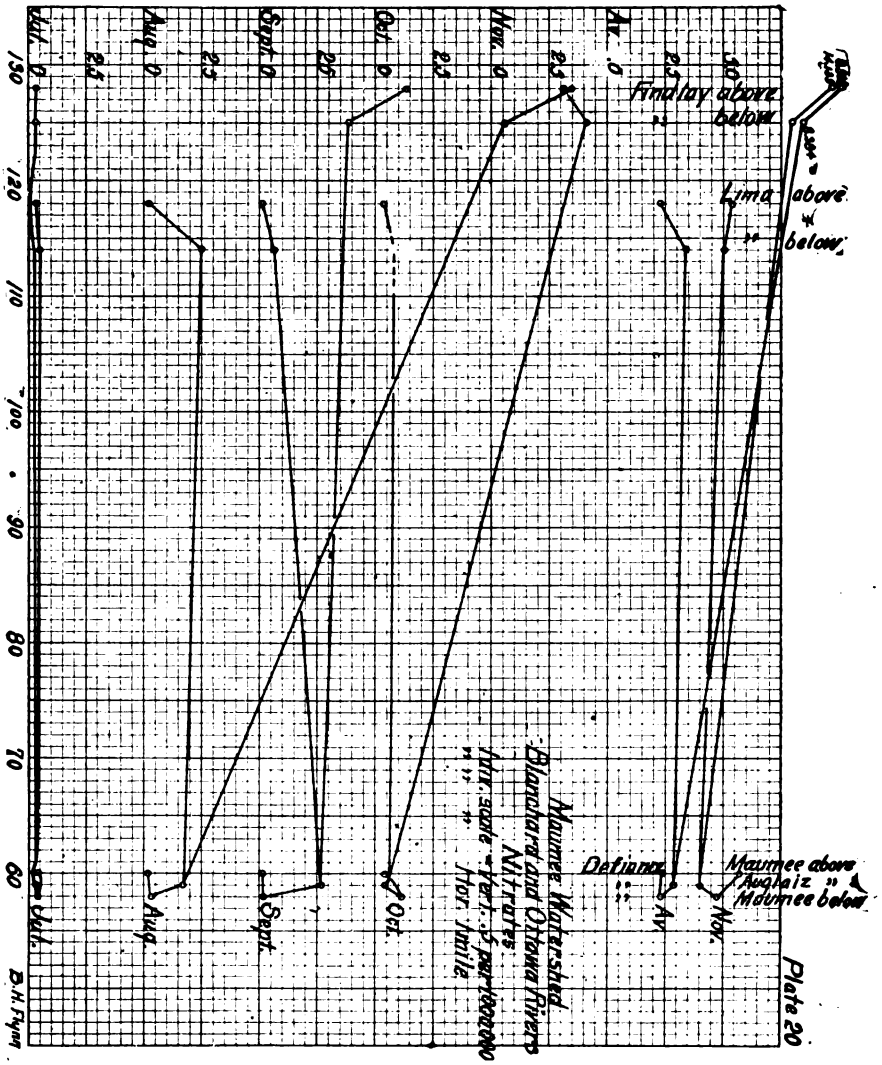


Plate 19
Maumee River
Nitrites
1 div. scale = Vert. 1 per 1000
" " " = Hor. 2 miles
July
Aug.
Sept.
Oct.
Nov.
Average
Fort Wayne St. Mary dam
" " St. Joseph "
Maumee below
Defiance Maumee dam
Antwerp "
Maumee below
Napoleon dam
below
Toledo "
Nov.
Cherry St.
dam
Riverside
Av.
B. H. Flynn


Findlay above
" below
Lima above
" below
Defiance
" "
Maumee above Auglaiz "
Maumee below
Maumee Watershed
Blanchard and Ottawa Rivers
Nitrates
Aug.
Sept.
Oct.
Nov.
Dec.
Plate 20

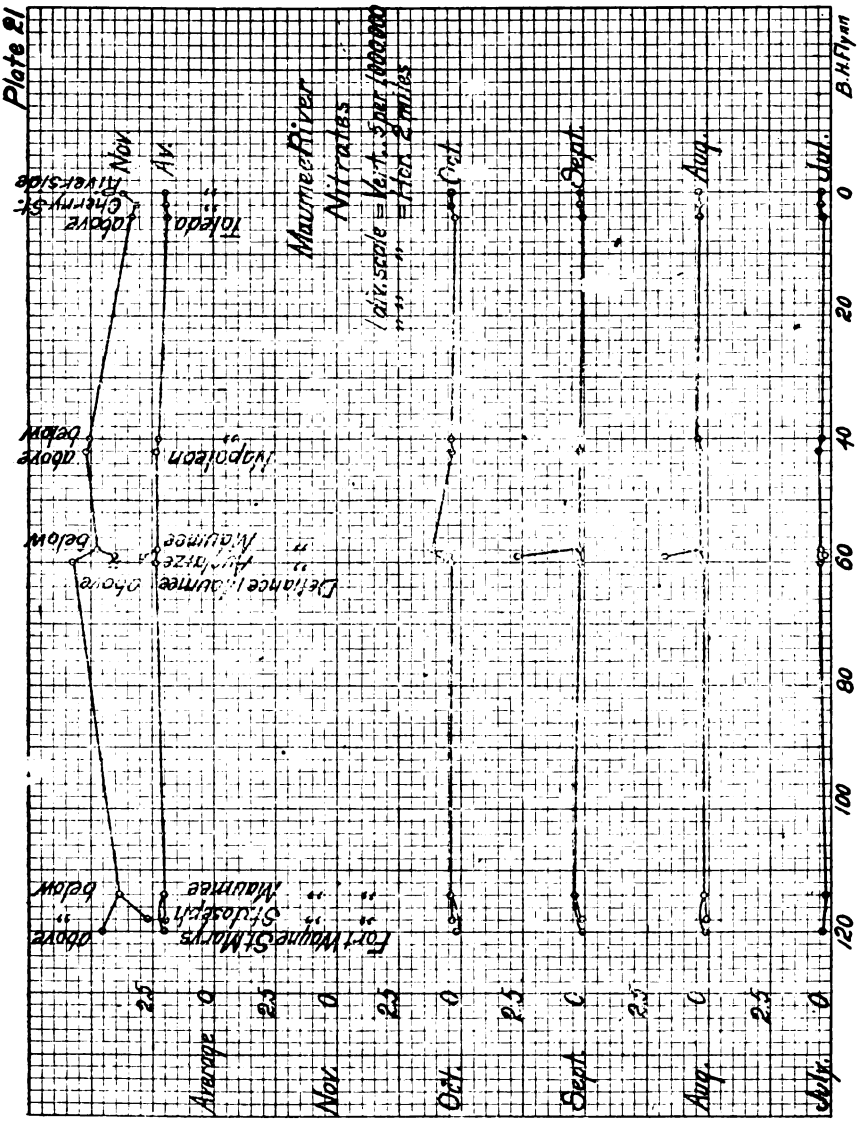
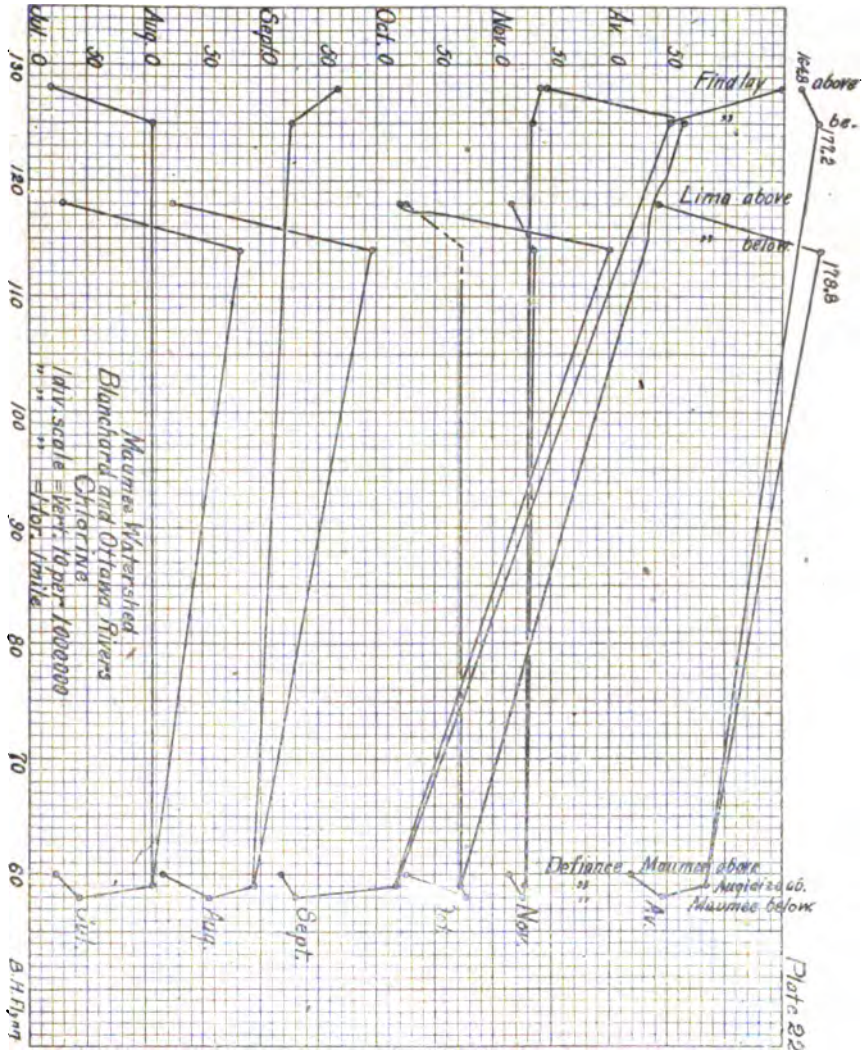


Plate 21
Maumee River
Nitrates
div. scale = ½ p.p.m. per 1000000
" " " = 1 ten 2 miles
B.H. Flynn
July
Aug.
Sept.
Oct.
Nov.
Average
Fort Wayne
St Marys
" "
St Joseph
" "
Maumee
" "
above
below
Defiance
Maumee
" "
above
below
Napoleon
"
Toledo
"
Lobdell
Chenny St.
Riverside
May
Nov.


Findlay
Lima above
below
Maumee Watershed
Blanchard and Ottawa Rivers
Chlorine
Aug.
Sept.
Nov.
Defiance
Maumee above
Augl. 2 & 6.
Maumee below
Plate 22

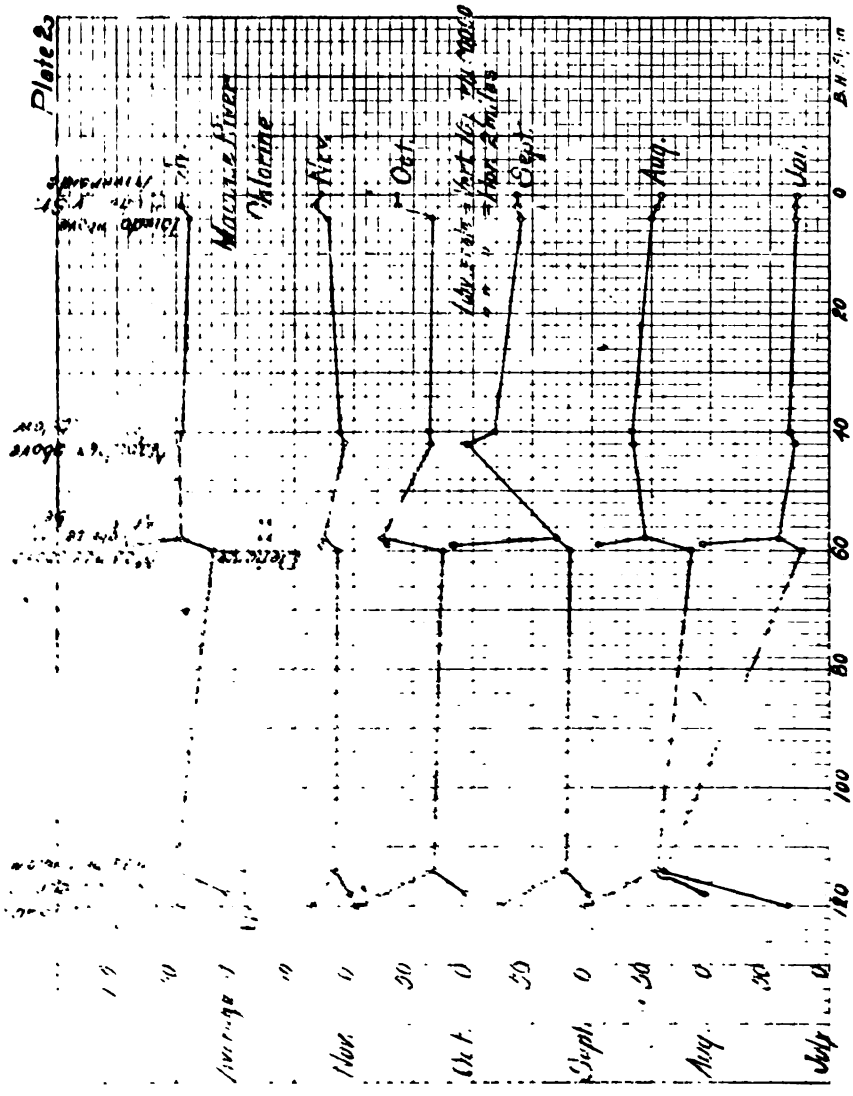
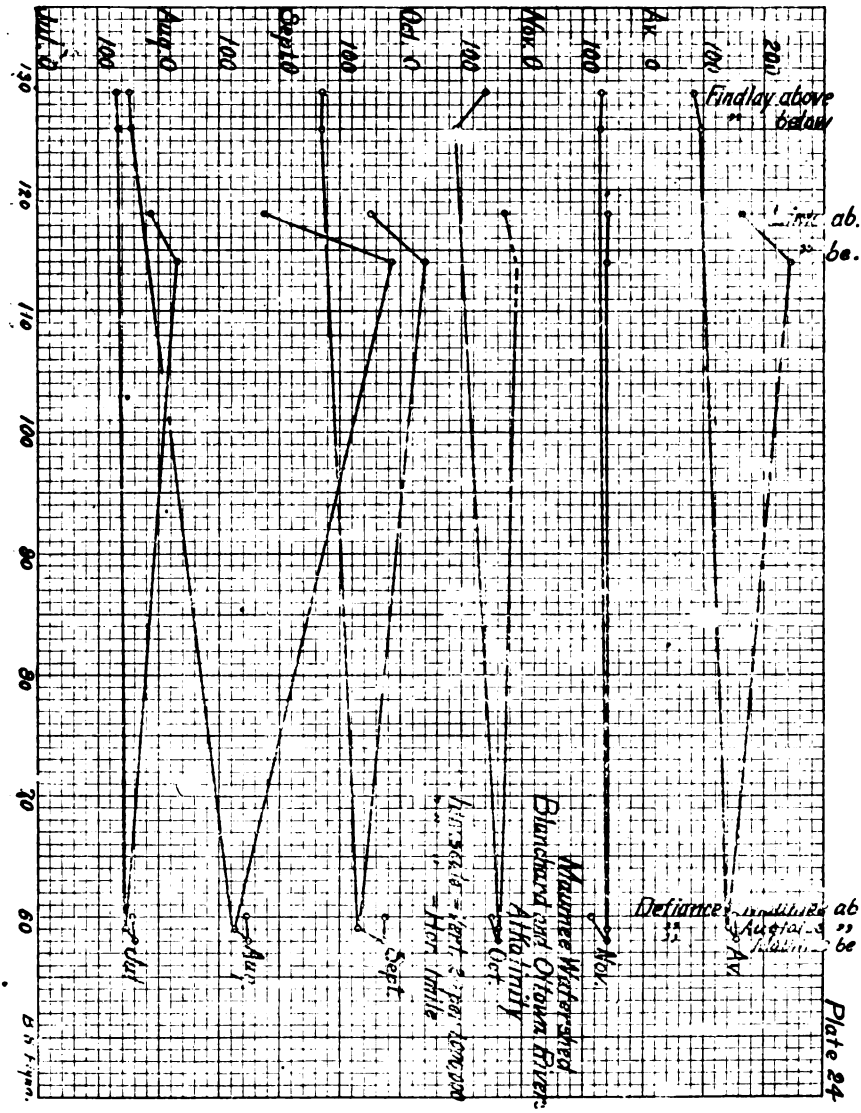


Plate 23
Nov.
Oct.
Sept.
Aug.
July
0
20
40
60
80
100
120


Findlay above
" below
ab.
be.
Defiance
" ab
" be
Maumee Watershed
Blanchard and Ottawa River
Alkalinity
Plate 24

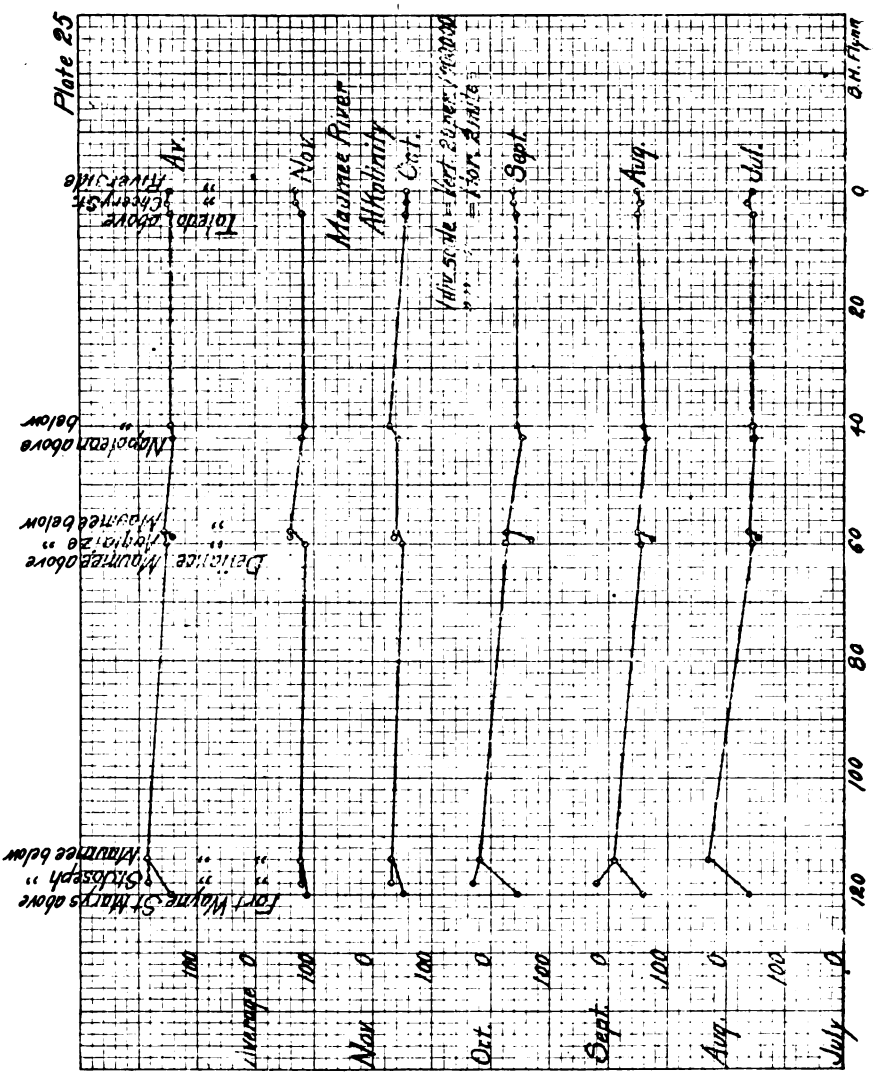
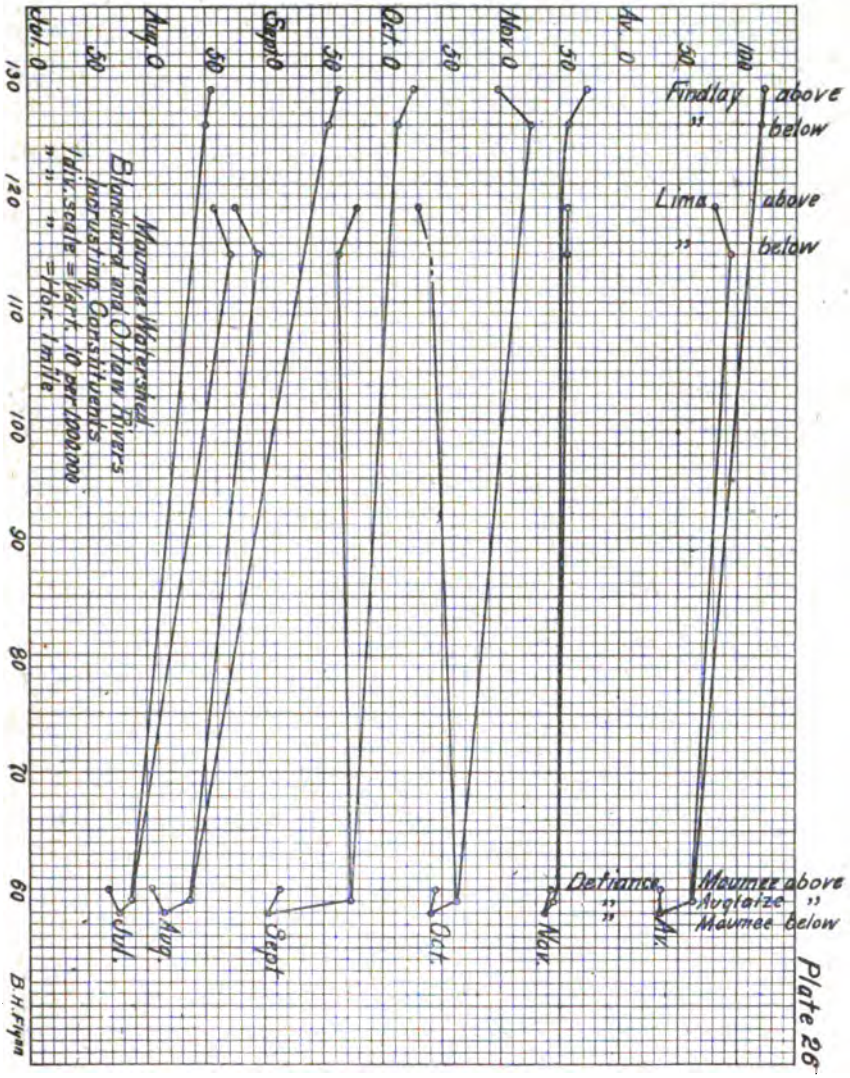


Plate 25
Maumee River
Alkalinity
Cal.
Nov.
Sept.
Aug.
July
Av.
Toledo odors
" Chestnut St
" Riverside
Napoleon odors
" below
Defiance Maumee odors
" Virginia "
" Maumee below
Fort Wayne St Marys odors
" Tiffin " "
" Maumee below
Average
Nov.
Oct.
Sept.
Aug.
July
0
20
40
60
80
100
120


Findlay above
" below
Lima above
" below
Maumee Watershed
Blanchard and Ottawa Rivers
showing Constituents
Vert. scale = Vert. 10 per 1000000
" " = Hor. 1 mile
Defiance, Maumee above
" Auglaize "
" Maumee below
Jul.
Aug.
Sept.
Oct.
Nov.
Dec.
B.H.Flynn
Plate 26

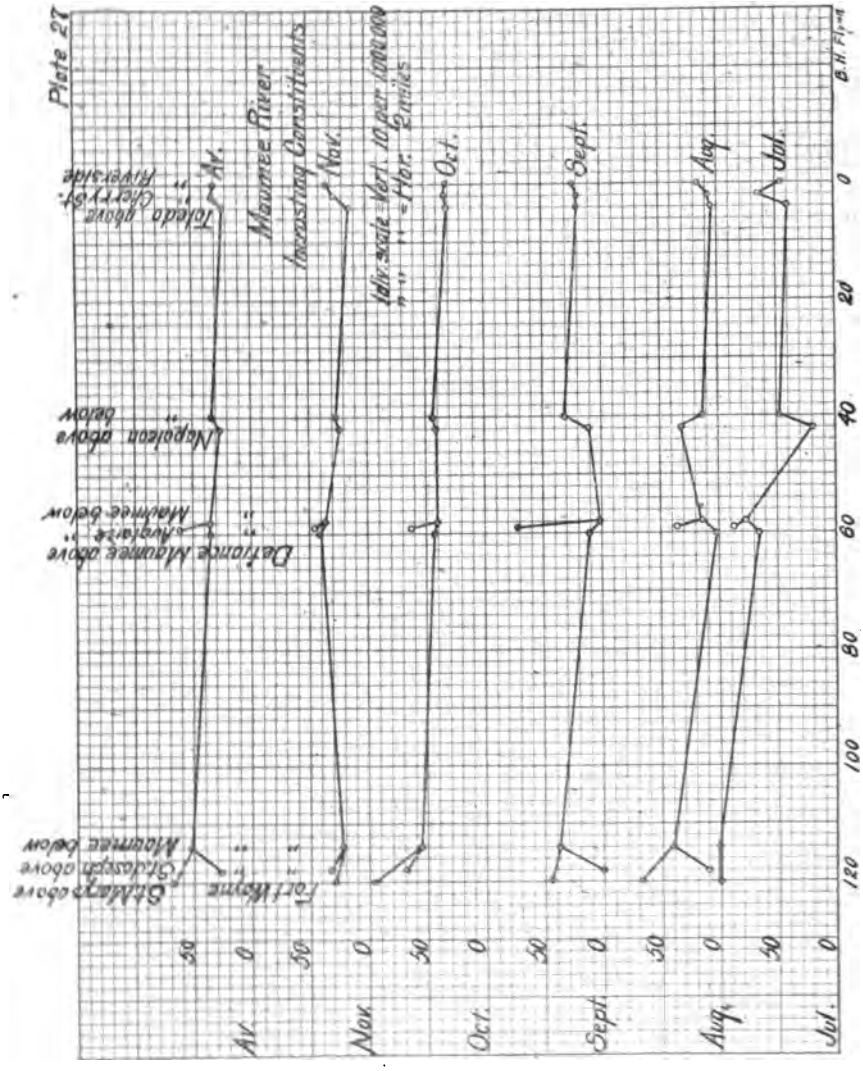
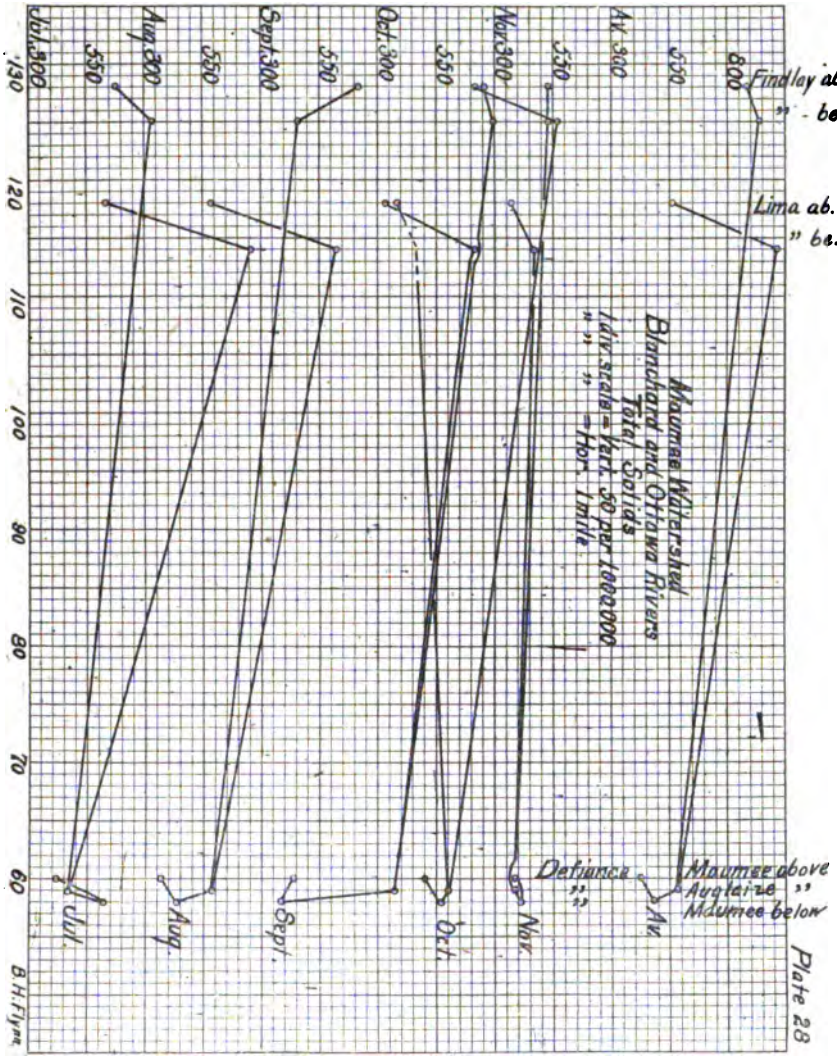


Plate 27
Milwaukee River
Increasing Constituents
Nov.
Oct.
Sept.
Aug.
Jul.
Av.
Nov.
Oct.
Sept.
Aug.
Jul.
Toledo above Cherry St.
" " Riverside
Napoleon above
" below
Dayton Miamee above
" " Miamee below
Delphos above
Fort Wayne " "
Girardeau above
Miamee below
B.H. Fig.=1
0
20
40
60
80
100
120


Findlay ab.
" be.
Lima ab.
" be.
Maumee Watershed
Blanchard and Ottawa Rivers
Total Solids
1 div. scale = Vert. 50 per 1000000
" " " = Hor. 1 mile
Defiance
" "
Maumee above
Auglaize "
Maumee below
Jul.
Aug.
Sept.
Oct.
Nov.
Dec.
Plate 28
B. H. Flynn

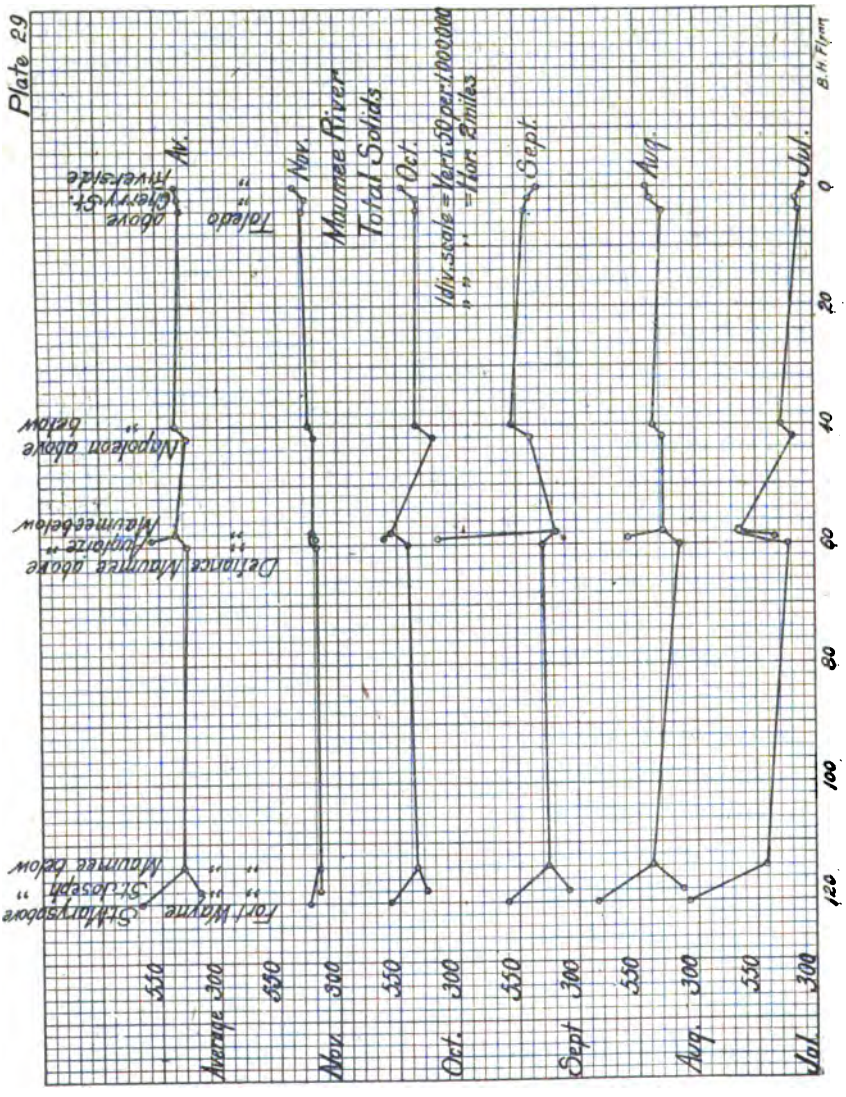
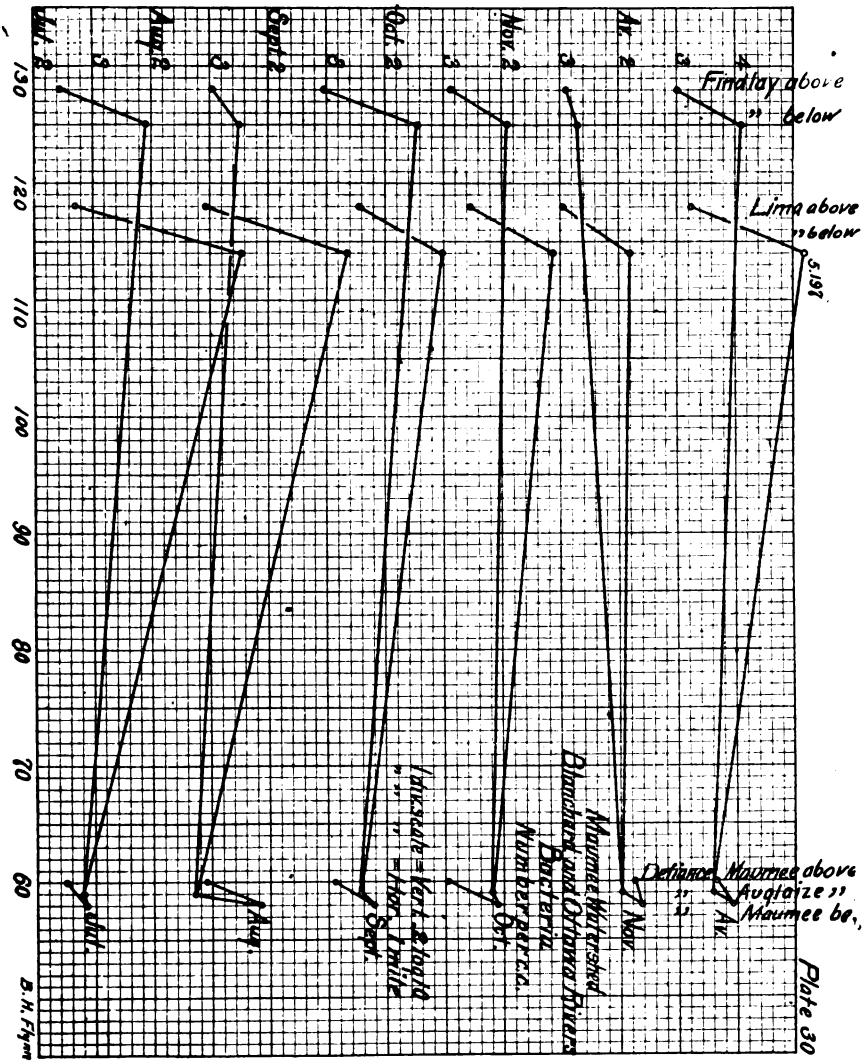


Plate 29
B. H. Flynn
Maumee River
Total Solids
Oct.
Nov.
Sept.
Aug.
Jul.
Horiz. scale = Vert. 50 per 1000000
" " " = 1 for 2 miles
0
20
40
60
80
100
120
Average 300
330
350
Oct. 300
350
Sept 300
350
Aug. 300
350
Jul. 300
Fort Wayne
" "
Stillwater
St. Joseph
" "
Maumee below
Toledo
" "
Napoleon above
" below
Defiance Maumee above
" Tiffin "
" Maumee below
Mr.
above Cherry St.
Riverside


Findlay above
" below
Lima above
" below
5.19
Defiance Maumee above
" Auglaize "
" Maumee be.
Plate 30
Maumee Wabash and Miami Rivers
Bacteria
Numbers per c.c.
Lakeside = Kent & Lloyd
" " = Hoe Davis
B. H. Flynn

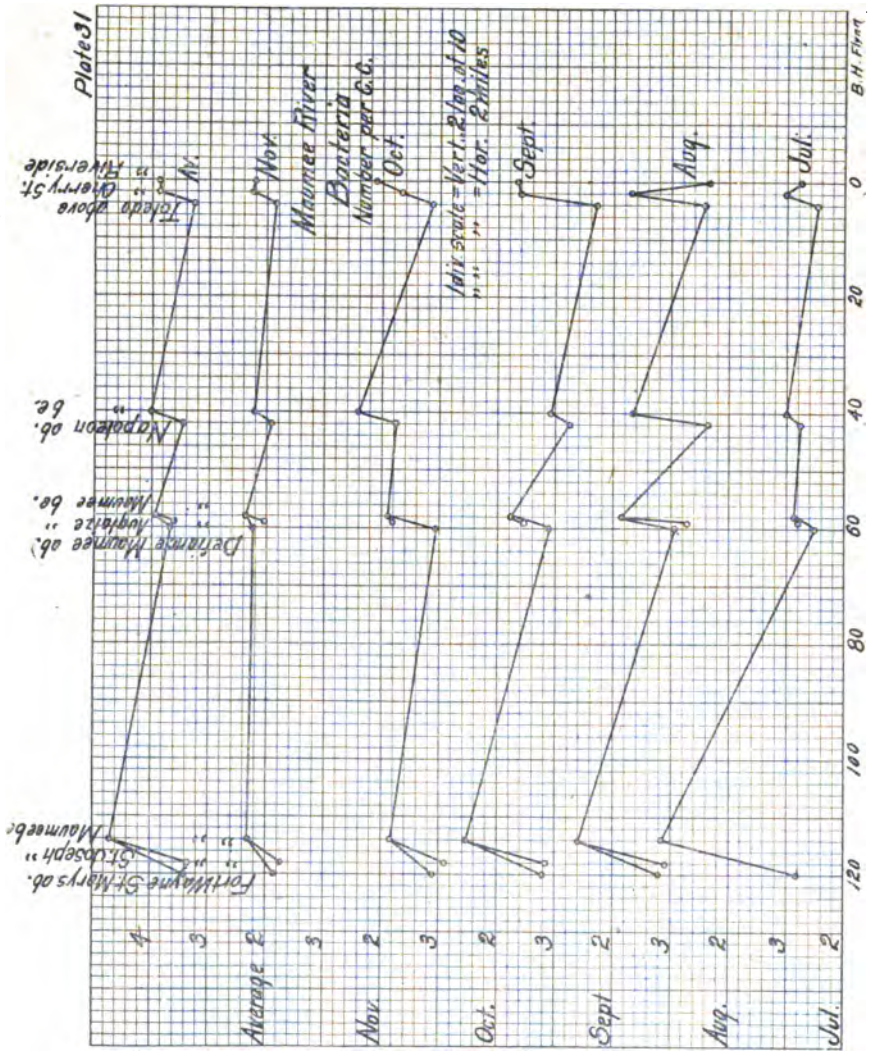
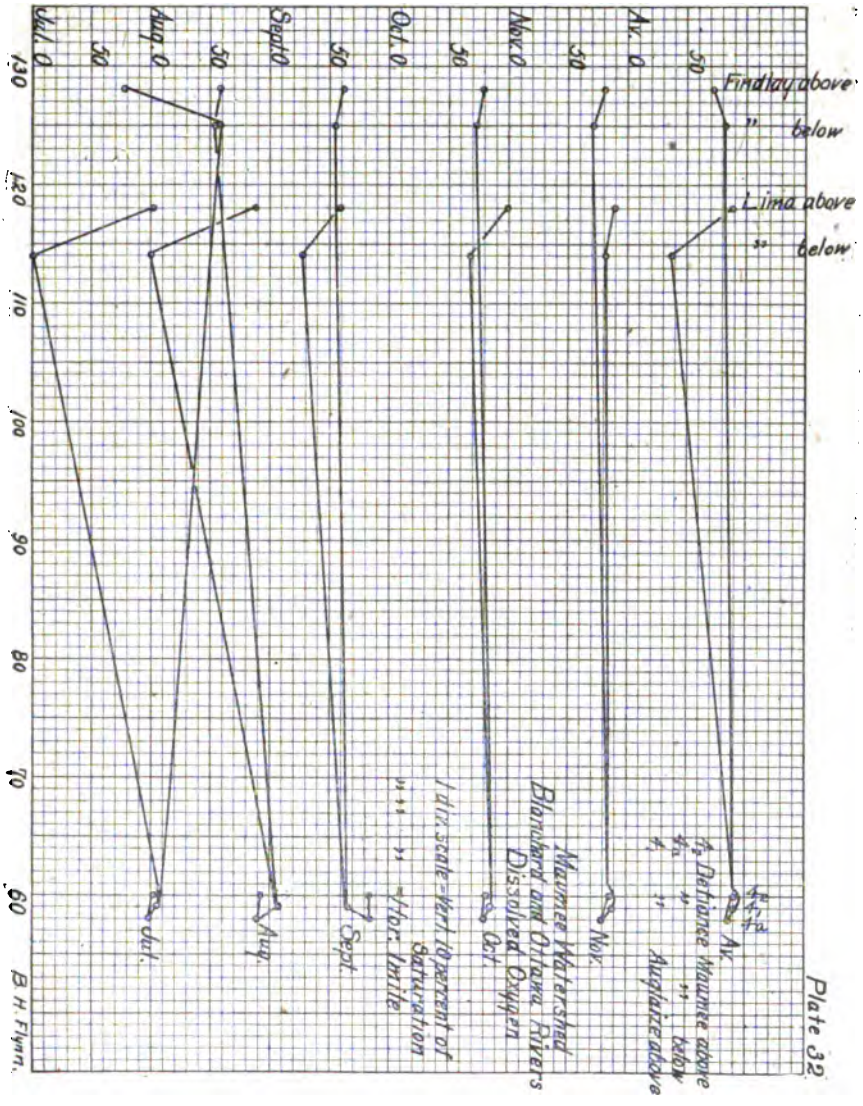


Plate 31
Maumee River
Backeria
Number per c.c.
Oct.
Nov.
Sept
Aug.
Jul.
Average
Index scale = Vert. 2 to 1 = 10
" " = Hor. 2 miles
B.H. Flint
0
20
40
60
80
100
120
Fort Wayne St. Marys ob.
" " St. Joseph "
" " Maumee
Defiance Maumee ob.
" Napoleon "
" Maumee be.
Napoleon ob.
" be.
Toledo above
" Cherry St.
" Riverside
Jul.
Aug.
Sept.
Oct.
Nov.
Dec.


Findlay above
" below
Lima above
" below
Maumee Watershed
Blanchard and Ottawa Rivers
Dissolved Oxygen
Jul.
Aug.
Sept.
Oct.
Nov.
Dec.
Plate 32
B. H. Flynn.

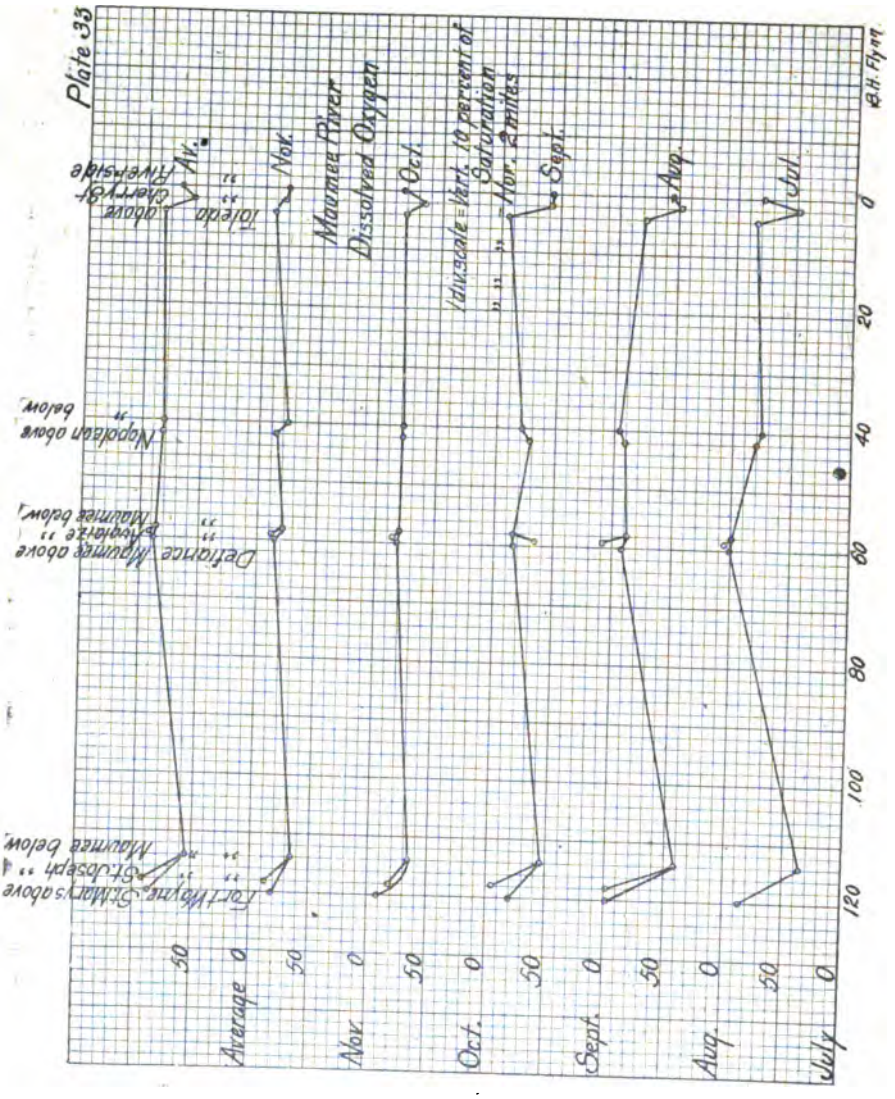


Plate 33
Maumee River
Dissolved Oxygen
Vert. scale = Vert. 10 percent of Saturation
" " " Hor. 2 miles
Nov.
Oct.
Sept.
Aug.
July
Average
Nov.
Oct.
Sept.
Aug.
July
Toledo " Av.
" " Nov.
" " Oct.
" " Sept.
" " Aug.
" " July
Fort Wayne, Stillwater's above
" " Otsego " "
" " Maumee below
Defiance Maumee above
" Tributaries "
" Maumee below
Napoleon above
" below
B.H. Flynn
0
20
40
60
80
100
120
50
0
50
0
50
0
50
0
50
0

DISCUSSION OF TABLES AND PLATES.

SANDUSKY WATERSHED.

PHYSICAL CHARACTERS. The water of the Sandusky river shows considerable color which remains nearly uniform throughout the stream except below Crestline and Bucyrus, rising especially at these points in times of low water. The water of this stream, in 60 per cent. of the samples taken, gave a prominent urbidity mostly due to the suspended clay in a finely divided state. Clay is found quite abundantly along the course of the river. The sediment was slight except in times of high water or at the stations below Crestline and Bucyrus, where much pollution was present. The stream is not an odorless one—but five samples during the season yielding no odor, while many of the samples were undesirable, and some were bad. On the whole the odor of the water would frequently make it undesirable as a public water supply.

CHEMICAL CHARACTERS. *Oxygen required.* Here we find evidence of the presence of a large amount of organic matter for nowhere in the river do we find a low oxygen requirement, while the average of all the determinations is nearly 7½ parts to the million. The curves (Plate 1) show that in general there occurs, as would be expected, an increase in the oxygen requirement wherever organic pollution is found. This is especially noticeable at Crestline and Bucyrus where in the summer the stream is so small—a mere brook—that the sewage produces a marked effect. In connection with the fall of the November curve at Bucyrus, it should be borne in mind that the river had overflowed its banks to such an extent that the collector could not get within fifteen rods of the usual sampling place, and consequently took his sample at the edge of the greatly widened stream. A sample from the current would doubtless have yielded other results.

Nitrogen in the Form of Albuminoid Ammonia. It was found that the albuminoid and free ammonias were in this river subjected to fewer local disturbances than the other determinations and, accordingly, they are the best indicators of the sanitary condition of the water. The albuminoid ammonia curves (Plate 2) with striking regularity rise at known points of pollution and fall in the intervals by virtue of the processes of natural purification. It will be noticed that both the free and albuminoid ammonia curves fall but little (best shown in the curve of averages) from below Upper Sandusky to above Tiffin. This does not mean so much

the lack of purification in that distance as lack of pollution at Upper Sandusky. By reference to Mr. Flynn's report it is seen that Upper Sandusky does not contribute so much sewage to the river as its population would lead one to think. The average amount of nitrogen occurring as ammonia is but slightly higher above Tiffin than above Upper Sandusky. The course of the November curve at Fremont is unexpected, but is similar to that of the oxygen requirement, whereas the curves for chlorine and free ammonia take the usual course at that time. The cause was undoubtedly a local vegetable pollution affecting the above Fremont sample. Such a pollution might readily occur under the weather conditions prevailing at the time.

The determinations of the *nitrogen in the form of free ammonia* with the resulting curves (Plate 3) are very satisfactory, and point out admirably the sewage pollution condition of the stream at the points where samples were taken. The curve rises with each addition of sewage and then falls until the sewage of the next lower town is received. The July sample below Upper Sandusky does not represent the full extent of the local pollution as it was taken, through lack of information, above the mouth of one of the sewers. The effect of rain in making the water more uniform as regards its free ammonia nitrogen is seen in the flat November curve and similarly, but to a less degree, in the August curve. By consulting the discussion of the weather conditions it will be seen that the November sampling was at flood time and the August sampling immediately after summer rains.

The wide fluctuations of the curves at Crestline and Bucyrus indicate here, as in other determinations, much pollution in little water. It is not to be thought in studying the July curves that the sudden drop from station 1*a* to 1*b* (Crestline two miles below to Crestline three miles below) is indicative of any such rapid purification in the short space of one mile as the curves might suggest. The result is due in great part to dilution. Station 1*a* was taken on what is locally and logically known as "Stink creek," a mere open sewer across which one could step in some places, but which carries the sewage of Crestline. Within the next mile, however, Stink creek is joined by two other streams resulting in a fairly respectable body of water at Station 1*b*, although but one mile from the former station.

Nitrogen as Nitrites and Nitrates. (Plates 4 and 5). The nitrites represent the intermediate stage between the ammonias and the nitrates whether the process be the oxidation of the ammonia to nitrates or the reduction of the nitric acid to ammonia. When organic matter has reached the form of nitrates it is in its least objectionable state, and is then frequently spoken of as the evidence of previous

sewage contamination. However, the amount of nitrates in a river does not represent the full amount of previous contamination for some proportion of the nitrates would be taken up by growing vegetation. It will be seen by consulting the plates that nitrites are present below each known addition of sewage showing that oxidation of the organic matter had already begun, and in many cases we find oxidation had gone far enough to show an increase in the nitrates. Had our below town samples been taken closer to pollution, or had the stream been swift in its flow so as to have brought the pollution more quickly and consequently unchanged, to the below town stations, the nitrate curves would have been different. As it was the distance and the slow flow gave time for the oxidizing agents to produce an increase in the nitrates. Even in those places where the percentage of sewage was greatest we find this occurring. By consulting the report of Mr. Flynn it wi be seen that below Crestline and below Bucyrus the exposed condition, the shallowness of the stream, the broken flow and the vegetation furnish conditions favorable to oxidation. In connection with the exceedingly high amounts of nitrous and nitric acid at Crestline in July, we would call attention to the fact that the free ammonia is lower. Owing to the dry weather conditions in that month the stream was unusually low, and the flow was very slight. The influence of the fall rains in making the water of the stream richer in nitrates is not so noticeable in the Sandusky river as in the Maumee and those examined last year. The nitrate determinations for November are, however, somewhat higher than during the rest of the season.

Chlorine. (Plate 6). As the amount of chlorine in the water changes only by the addition of more chlorine or by dilution of the water, its determination is one of those most sought as an indicator of sewage pollution. This value as an indicator depends, however, on the absence of chlorine from mineral sources, and accordingly the presence of mineral chlorine makes this determination an unreliable one in establishing the presence or absence of sewage pollution. In a river free from mineral chlorine the curve would by rising point to each sewage pollution, and by falling show the addition of water containing a less amount of chlorine. The water of the Sandusky river is high in chlorine throughout its course. The effect of dilution is seen in the November samples when all of the results were much lower, and the various samples differed less from each other, as shown by the smoother curve. The curves show an increase of chlorine for the addition of sewage except once at Bucyrus, once at Upper Sandusky, and three times at Tiffin. The cause for the direction of the curve at Bucyrus in September is not apparent. We would mention in this connection that although the rainfall table gives

no precipitation for the two days preceding the taking of the September samples at Bucyrus, nevertheless the field note book of the writer says he was informed when taking the samples that quite a rain had fallen on the two days previous. The roily condition of the water sustained the information thus recorded. The cause for a similar decrease in the chlorine at Upper Sandusky in October is likewise not apparent but there must have been some dilution associated with the lower sample, or too high a figure above town resulting from some local pollution. It was learned at the close of the season that there is a spring in the bed of the river near the sampling point below Tiffin. The influence of such a fresh water source could easily lower the chlorine character of a sample taken near it, but why this should have occurred in three out of five samples and not in the others does not seem clear.

Perhaps the most striking thing in Plate 6 is the great increase of chlorine between Upper Sandusky and Tiffin. This occurred each month save August, and is well shown in the curve of averages. Between the two places named the Sandusky river receives the waters of Honey, Sycamore and Tymochtee creeks. As these tributaries receive little or no sewage, and as their combined volume approximates that of the Sandusky, we would expect a decided lowering of the amount of chlorine to be shown above Tiffin. This actually occurred only in August, and then the chlorine appeared again at Fremont. This chlorine is not of sewage origin. After a personal inspection of the river between Upper Sandusky and Tiffin, the civil engineer of the State Board of Health says there is no sewage pollution to account for such an increase in chlorine. Furthermore, a study of the analytical results and plates shows this increase of chlorine to be unaccompanied by any corresponding increase in organic matter, with the exception, possibly, of November when the high water would result in diluting the chlorine, and increasing the organic matter. But one conclusion can be reached—this increase is due to chlorine of mineral origin and enters the river between Upper Sandusky and Tiffin. The exact location of this pollution was not attempted by analytical methods, and failed to be attained by inquiry and inspection. No oil wells are present in that territory, and no salt springs could be located although rumor were heard of "deer-licks" in years gone by. This rise in chlorine is greatest in July and October, when the samples represented the river under dry weather conditions, or just at the beginning of a rain, and is much less under the influence of the rains in August, September and November. It will be seen that the river maintains this high chlorine throughout its succeeding course—station 6 representing Sandusky bay water and not the river water. It would seem from the August curve that the addition of this extra chlorine had

been made between Tiffin and Fremont, but a study of the results for the other months gives no indication of chlorine pollution between Tiffin and Fremont. The peculiar August results finds a more probable explanation in the effect of the heavy rain which fell from 48 to 72 hours before the samples were taken at Tiffin, and which may have washed the chlorine past Tiffin, and yet not have had time to wash it past Fremont. This explanation finds support in the reverse condition of the curve in October, when the samples were taken so soon after a rainfall that the effect of the washing appeared only at Tiffin, not having had time to reach Fremont. This explanation of the peculiar features of the August and October curves rests in part upon the following assumption. The chlorine as it is about to enter the river gathers to some extent in such shape as to be partially held back until washed out under the influence of a sudden rain. In November the river was higher and no such result would appear. The source of this chlorine pollution may be intermitent, but it does not appear from the data at hand.

The *alkalinity*, (Plate 7), gives approximately the amounts of calcium and magnesium carbonates. The curve of the averages shows the carbonates were fairly uniform throughout the stream, with the exception that they are higher below Crestline. At that station the alkalinity was low for some cause in September, and again in November. In the latter month the stream was full from fall rains and this addition of rain water would naturally lower the results. The sewage and other pollutions of the towns and cities increase the carbonates as seen best from the curve for the averages. This effect is greatest at Crestline where the sewage is but little diluted. The Sandusky river water is richer in carbonates than the Mahoning, though not so rich as that of the Scioto and Olentangy rivers, while it is nearly the same as the Maumee water.

Incrusting Constituents. (Plate 8). As stated before these are chiefly sulphates and chlorides of calcium and magnesium and are the formers of the scale found in boilers. The curve of averages is quite regular and shows, like the alkalinity, an increase on the addition of the city pollutions. This means that the sewage of the various places along the stream is harder than the river water itself. The water of the river is hardest at Upper Sandusky and Tiffin, although there is but a slight decrease for Fremont.

The *total solids* (Plate 9), follow in general the alkalinity and incrusting constituents, and also show the presence of the alkaline salts at Crestline, Tiffin and Fremont.

Dissolved Oxygen. (Plate 11). In the work upon the Scioto and Olentangy rivers last year, several samples of water were found containing a greater amount of oxygen than is given by tables as the amount which distilled

water takes up when saturated with air. The results were obtained with care and duplicated. We anticipated the same feature in the present work, and accordingly desired to carefully examine the water biologically at those places where supersaturation appeared in the Sandusky and Maumee watersheds, but the stress of the regular routine work prevented any added investigations along other lines. This supersaturation is no doubt due to the oxygen given off in plant growth, as stated by Prof. Lord in his report upon the Scioto and Olentangy rivers. Out of 52 samples from the Sandusky river there were six cases of supersaturation. One was above Crestline in October, but as this was the only sample taken there except in the high water, November, it gives us little information of the normal condition. In September both the Tiffin samples showed supersaturation. The remaining three cases were above Bucyrus in the three summer months.

We expect the decrease in the amount of dissolved oxygen whenever sewage is added to the stream. With one or two exceptions that is what occurred, as may be seen from Plate 11. This is a natural sequence, as the purification of sewage is a process of oxidation, and the free oxygen in the water is quickly taken up by the organic matter so prevalent in sewage.

BACTERIAL FINDINGS ON SANDUSKY WATERSHED.

	July.	August.	September.	October.	November.	Average.
Crestline, above	.....	.....	.....	1,160	58,500	29,830
Crestline, below	65,350	30,210	46,800	18,095	222,300	76,551
Bucyrus, above	345	775	735	200	82,800	16,971
Bucyrus, below	295,800	29,260	24,070	5,381	175,000	105,902
Upper Sandusky, above	167	677	1,300	585	13,100	3,166
Upper Sandusky, below	610	8,440	40,320	5,070	31,900	17,268
Tiffin, above	133	1,590	820	1,155	16,980	4,134
Tiffin, below	5,700	9,720	4,140	37,400	53,000	21,992
Fremont, above	330	1,319	675	1,455	4,490	1,654
Fremont, below	4,725	11,060	4,730	11,400	5,060	7,395

Bacteria. (Plate 10). Without exception the bacterial curve rises under the influence of fresh sewage and falls again with conditions of natural purification. The intensity of the inflections agrees well with the degree of pollution. The greatest amplitude of the curve being at Crestline and Bucyrus during the stages of low water. This confirms the chemical findings. A stated in the previous report by Dr. Bleile, a sud den rain would bring into the river large numbers of bacteria in the

face washings, together with more or less organic matter suitable for their nourishment and subsequent propagation. This would result in an increase in the number of bacteria in the purer portions of the stream, while it would dilute the more badly polluted portions. With an increase of bacteria in the purer water and a decrease in the impurer water, as a result of recent rainfalls, a smoother curve would be obtained. This is shown in November and, to a less degree, in August. The November figures are misleading if they be taken as representative of the conditions throughout the month. No doubt the number of bacteria would be higher then as shown by the findings of other workers, but not as high as the figures here given for November. By reference to the dates of sampling and to the rainfall table it will be seen that the samples for that month were taken at flood time, and at the beginning of the sudden high water, when the bacterial effect of surface washings would be greatest. These extreme conditions would not long continue, and thus it is unfair to take the November figures, as representing the conditions for that month, in the same way as the other findings do for their months. Consequently the averages given in the table, although they do represent the mean number of bacteria in the five examinations should not be taken unconditionally as a basis for judging the water. On the other hand an average of the findings for July, August, September and October does represent the number of bacteria present under average conditions during that season of the year. A correct average for the season would be somewhere between the two averages.

The waters recently polluted are not the ones likely to be used, and so we will confine our inquiries to the purity of the water at above town stations, where the river would be expected to be at its best. The extreme effect of the November samples, as spoken of above, is strikingly shown in the following table of averages at the above town stations:

	Crestline.	Bucyrus.	Upper Sandusky.	Tiffin.	Fremont
	a	a	a	a	a
Average for season.....	29,830	16,971	3,166	4,134	1,654
Average omitting Nov..	1,160	514	682	924	945

But little value can be placed on the findings above Crestline, owing to unusual conditions in the only two months when there was sufficient water to cause a flow. In October the water had just begun to flow and would be higher bacterially than a water which had been regularly washing the bed of the river for some time. In November occurred the very high water conditions previously referred to. For these reasons we omit the station above Crestline, and speak of the four remaining ones. Beginning with Bucyrus above, we have an average of 514 bacteria per

c. c., with a steady increase at each successive station down the river. This increase is not large, but it would indicate that the water is being polluted faster than it purifies itself. There is little satisfaction in trying to establish a bacterial normal for this river with the information at hand. The October and November conditions above Crestline have been stated, and during the remaining months our uppermost sample contained Crestline sewage. The lowest results were obtained in July when the water was lowest, and were equaled but once during the remainder of the season, viz., above Bucyrus in October. By reference to Mr. Flynn's report it will be seen that while Tiffin is a thriving city of some 14,000 population, yet only 2,700 of these have access to sewer connections, and accordingly the pollution of the river is not as great as one might at first think from the size of the city. In addition to this there is a milldam one mile above our below-Tiffin station, and between it and the city. Again our sampling point was just above a second dam. These dams, by backing the water, furnish opportunities for sedimentation and thus would decrease the otherwise greater increase in bacteria below Tiffin. The results of the bacterial and chemical analyses indicate, that while the water of the Sandusky river may at times purify itself under favorable conditions, yet in general the pollution exceeds, to a greater or less degree, the amount of purification taking place by natural processes.

MAUMEE WATERSHED.

It is well before discussing the results to speak of certain disturbing factors. Oil wells are to be found in several parts of this watershed and the deep ground water they pump out is frequently saline. At Findlay are situated two factories for the manufacture of nitro-glycerine, and the wastes from these factories enter the Blanchard river—the outlet from one factory being above the upper station at Findlay and the other between the two stations. The writer is informed that the lower factory was in constant operation and the upper one nearly so. At Toledo boats of various sizes are passing back and forth with irregularity—especially is this true at Cherry street, and at Riverside Park. When one of the larger boats passes, the water is greatly stirred up, even at times bringing to the surface fragments of the nasty mud found at the bottom of the river. On both sides of the river at this place are manufacturing plants of various kinds. The uncertainty of obtaining samples which would truly represent the river under these conditions is so great that we shall not attempt to explain some of the irregularities to be found in the results at Toledo.

PHYSICAL CHARACTERS. The color of the Maumee river water, especially in its lower course, is slightly less than that of the Sandusky. The Ottawa and Blanchard tributaries are quite highly colored at Lima and Findlay—this being increased in times of low water. The turbidity of the Maumee is similar to and slightly greater than that of the Sandusky. The slow current is favorable to sedimentation and but little sediment is found, except in high water. The volume of the Maumee would lead us to expect but little odor from specific pollutions, and yet the water falls short of a desirable one in this respect. At times the samples from Findlay, Lima and Ft. Wayne yielded extremely objectionable odors. In but one of the five samples above Findlay was the water odorless and three times this feature was such as to make the water unpalatable.

CHEMICAL CHARACTERS. The *oxygen requirement* (Plates 12 and 13) is even higher in this river than in the one previously discussed and is of little, if any, value in determining sewage pollution. In the lower portion of their courses where the waters run more uniform in their oxygen requirement the Maumee determinations ran about two parts to the million higher than did those of the Sandusky. The excessive increase in the oxygen required at Lima in July, August and September was due to the fact that the stream below town was mainly composed of sewage and the washings from the strawboard mill. Much of the oxygen required was due to the latter element, as is shown by comparing Plates 12 and 14; for had it been due to sewage the albuminoid ammonia would also have been higher. The comparison shows the vegetable pollution to be carbonaceous rather than nitrogenous in character. The October sample was unfortunately lost by the bottle being broken in transit. In November the condition was changed; the stream was full from the fall rains and while increasing the oxygen requirement at other places by virtue of the vegetable matter washed in by the rains, yet it served to dilute, below Lima, the water already high in required oxygen. The long flow of more than fifty miles to the Defiance station on the Auglaize river furnishes opportunity for change and we find at the latter station this requirement, except in September, to be approximately as low as the Maumee at that place. A very severe rain and wind storm occurred September 24, on the area drained by the Ottawa river, and its effect is seen in the high figures for that month above Lima and below Defiance on the Auglaize. While showing an increase at those places due to the vegetable matter washed in, yet the otherwise high oxygen requirement below Lima would be lowered by this dilution, as stated before A comparison of the conditions above Defiance in October and November on Plates 12 and 14 show by the oxygen required and the nitrogen as albu-

minoid ammonia that, when both streams are full from uniform wet conditions, the Maumee comes down to Defiance with a greater vegetable pollution than does the Auglaize. This is compatible with the fact that acres of the upper Maumee watershed are covered with remains of vegetation as shown by the report of the engineer, and under continued wet weather this could produce the above results. The descent of the curve at Napoleon in November is unexpected, but seems to be in some way associated with the high waters. The averaging of results at Defiance includes the effect of Tiffin river, which enters the Maumee just below the upper station at Defiance.

Nitrogen as Albuminoid and Free Ammonia. (Plates 14–17). As in the case of the Sandusky river these determinations were interfered with by disturbing local factors and accordingly may be taken as the most reliable indicators of the extent of sewage pollution. The two sets of curves are quite similar, month by month, and, except in one or two instances, agree closely with the known pollution. In November the amount of free ammonia below Defiance is nearly a mean of the amounts above that city on the Auglaize and on the Maumee. This would be a natural sequence without the sewage of Defiance, as the volumes of the two streams are nearly equal. In the absence of information from gagings we estimate the relative volumes of the two streams by the area drained.

The Auglaize drains 2,504 square miles and the Maumee above Defiance, approximately, 2,230 square miles. It should not be overlooked that the Tiffin river, with a drainage area of 669 square miles, empties into the Maumee just below the upper station at Defiance. As shown by the report of Mr. Flynn the pollution of this river is slight and at such a distance that the water would be well purified by the time it reaches the Maumee and consequently offset, to a considerable degree, the pollution from the city of Defiance. In fact the results show that in November when the streams were high there was a small decrease in the albuminoid ammonia at the station below Defiance. The marked inflections of the free ammonia curves (Plates 16–17) show the addition of considerable quantities of fresh sewage at Findlay, Lima, Ft. Wayne and Toledo. The usual effect upon the free ammonia in rivers at time of high water is seen in the smoother November curve. The condition at Findlay is an interesting one being the result of several complications. One might think from the chlorine and nitrogen determinations that an excessive sewage pollution had occurred above Findlay, but this is not the case. Mr. Flynn's report shows the only towns on the Blanchard river above Findlay are Forest and Dunkirk, and neither of these small places empty sewage into the river. Consequently the high results must be due to ther causes. The chlorine, as will be shown later, is mineral in origin and

is introduced by the salt water from the oil wells. The nitrogen as nitrites and nitrates is due to the washings from the nitro-glycerine factories. Some of the free ammonia may be due to the reduction of the nitrous and nitric acid by iron, if the acid comes in contact with iron pipes. Volume II, Geological Survey of Ohio, page 353, says that there are in Hardin county three marshes of a somewhat peaty nature, covering some forty thousand acres. One of these, Cranberry marsh, drains to the Blanchard river, and its natural drainage was made more effective by ditching at the time our examinations were made. This peaty water would account for the albuminoid ammonia. A portion of the organic matter would be decomposed and yield free ammonia. This accounts for the excess of nitrogen as ammonia. The further discussion of this triple pollution of salt, peaty water and acid will appear under the next two headings.

Nitrogen as Nitrites and Nitrates. (Plates 18–21). The increase in nitrous acid at the known places of sewage pollution is well shown. The great increase of nitric acid throughout the stream in November agrees with the results obtained last year on the Scioto and Olentangy rivers. The cold and wet weather had resulted in cessation of plant growth and in much soil washing, and thus the water was unusually rich in nitrates. We would say that while the figures and the curve for the averages show the average of the five samples for each place, yet it should not be assumed that these figures represent the average condition of the water during the five months the river was under consideration. On the contrary, the figures for the averages are misleading, as they are too high, due to the special November conditions. The samples of that month were taken at flood time just after the heavy fall rains. The nitrates are greatly increased after the sudden rise by virtue of the soil washings, and would soon decrease even though the water remained high. Accordingly the conditions at the time of the November sampling were favorable to an unusually high proportion of nitrates, probably seldom equalled during the season, and then for a limited number of days only. Consequently to take the high results of a limited period as representing the condition for the month would be unfair, and would yield too high a figure in averaging results with other determinations which do more properly represent the character of the water throughout their months. A very striking thing in these curves is the variation at Findlay. (Plates 18 and 20). Only in the month of July do the amounts of nitrogen in the form of nitrites and nitrates remain low enough above Findlay to be at all desirable, while the averages for the season are:

	N. as nitrites.	N. as nitrates.
Above Findlay.....	.056	9.505
Below "	.102	8 384

These high figures result from the waste washings from the nitro-glycerine factories. In the process of manufacturing nitro-glycerine acids are used and subsequently the product is washed to free it from superfluous acid. Thus a considerable amount of acid reaches the Blanchard river. The writer is informed that the dead vegetation along the sewer ditch outlet from the upper factory shows the characteristic effect produced by acid. In this sewer ditch the refuse from the factory gathers in pools to be washed out in times of rain. This may account for the lower results in July, as we are informed that the factories are in operation nearly if not all the time. From the rainfall table it will be seen that no rain had fallen on the four days preceding the July sampling, and less than one-half inch in twelve days. The samples of the remaining four months were taken as follows: August, within 24 hours after a precipiation of 1.07 inches; September, two days after a light rain which was preceded 48 hours by a rainfall of nearly one inch; October, after a series of rains; November, after a period of excessive precipitation yielding full streams for some time. From the weather conditions and the nature of the ditch we would expect high nitrites and nitrates in our August, September and October samples, with somewhat lower results in November and still lower ones in July. That is just what did occur. The low figures in July may have been in part helped by the following circumstance: Although no rain fell at Findlay on July 20, the field note book of the writer states that under date of July 21, he was informed when taking the sample that "there was a heavy rain up the river yesterday and the river rose eight inches." This heavy rain up stream and yet not at Findlay would, by increasing the amount of water in the river without increasing the pollution from the glycerine factory's ditch, yield lower amounts of nitrogen above town in July.

Chlorine. A good introduction to the study of this phase of the Maumee watershed may be found in last year's report on the Examination of Sources of Public Water Supplies, pages 192–197. From Dr. Orton's description of the mineral character of the water produced by the oil and gas wells found on so large a part of the area drained by the Maumee river, we are not surprised when we note the high chlorine findings and the irregular curves. These findings are worthless as indicators of the sewage pollution of the stream under consideration. It takes but a very brief comparison of the analytical results and the curves for chlorine and free ammonia to see that they do not agree as they should under ordinary circumstances. While it is true that the chlorine curves in general show an increase at the points of known sewage pollution, yet the absolute amounts are so high as to frequently exceed the chlorine possibilities of sewage. The figures given for London sewage are 150.

parts per 1,000,000, while the water above Findlay in September yielded 449.5 parts of chlorine. This amount is not so surprising when we remember that oil wells sometimes throw out brine in their pumpings, and that there are possibly 15 oil wells above Findlay. With such saline conditions at the city last named, at Lima, and as the engineer reports at the head waters of the Auglaize river, it is not strange that the river named comes down to its junction with the Maumee so highly charged with chlorine that a great drop occurs regularly in the curve below Defiance as a consequence of the dilution by the water of the Maumee proper and more particularly of its northern tributaries. The effect of salt is found in four of the five branches of the Maumee examined—the only one showing an approximately normal amount being the St. Joseph river. This stream yielded an average of 3.6 parts of chlorine per 1,000,000, which could almost be expected from the population on the area it drained. On the other hand the population on the St. Mary could not by natural processes yield an average chlorine of 69.3 parts per 1,000,000. This amount is again unquestionably of a mineral character. As the results must therefore be more or less uncertain no further discussion of this factor will be made except of the condition at Lima. The findings at this place show mineral pollution both below and above town, especially so at the latter place in September. The regular and great increase shown below Lima should not be ascribed entirely to the influence of the sewage of that city. It seems that the public water supply of Lima contains more or less sodium chloride. In December, 1898, a request came to the State Board of Health for an examination of the public water supply of Lima. An examination made on December 16 revealed 1067. parts of chlorine per 1,000,000. No doubt it was unusually high at this time, but this would indicate the possibility of the presence of salt at all times. If a water as it is delivered to the consumers of a city be high in sodium chloride, we must find the water as it leaves the city, also high in the same ingredient, or there would soon be a people giving evidence of being descendants not of Adam, but of Lot's wife.

Alkalinity and Incrusting Constituents. (Plates 24–27). As stated previously the alkalinity is due chiefly to the carbonates of calcium and magnesium, while the chlorides and sulphates of calcium and magnesium furnish the incrusting constituents. The alkalinity represents temporary and the incrusting constituents permanent hardness. The Maumee is a little richer in carbonates and a little poorer in sulphates than the Sandusky river thereby differing from it but little in hardness. These streams have softer water than the Scioto and Olentangy but harder than the Mahoning. The water of the Maumee is hard as would be expected from the dolomite and limestone of the watershed. The deep

waters of this region are very rich in mineral matter as shown by last year's report. Due to the addition of water of this character we find an increased hardness in the Auglaize, Ottawa, and St. Mary tributaries. The water becomes softer in the lower course of the Maumee. As the streams reach Defiance the Auglaize water is harder than the Maumee, due to the larger proportion of sulphates and chlorides in the former stream. The sewage of the various towns and cities is harder than the river water. This is best shown at Ft. Wayne and Lima, and both of these cities are supplied with hard waters. The greatest alkalinity was found at Lima where the scale-forming elements are also high. The lowest average alkalinities were at the two Findlay stations, and in turn we found there the two highest average incrusting constituents. This is in accordance with the expected from the addition of the acid refuse from the nitro-glycerine factories. By reference to plates (24 and 26) or to the tables, it will be seen that free acid was present in the water both above and below Findlay, giving a negative alkalinity in August. It was in this month that the incrusting constituents here reached their maximum. It will be remembered that at the time of taking our August, Findlay samples, a heavy rain had fallen within the preceding twenty-four hours, thus favoring a decided influence upon the samples by the washing out of the acid from the ditch where it had gathered in pools. In this connection see pages 356 and 360.

The *total solids*, (Plates 28, 29), are high from the mineral character of the water, and follow very well the hardness as shown by the combined alkalinity and incrusting constituents. However, in making a comparison between these and the total solids, the chlorine character of the Maumee watershed should not be overlooked. The chlorides of calcium and magnesium would appear in the incrusting constituents while sodium chloride would not, yet all would show in the determination for chlorine and total solids. For example the high total solids above Findlay in September greatly exceed the combined alkalinity and incrusting constituents, and are largely due to the sodium chloride present. The same feature is shown in the results below Lima in July, August and September. Again the alkaline salts account for the fact that while the average hardness of the Maumee is less than that of the Scioto or Olentangy rivers, yet the former stream slightly exceeds each of the others in the average total solids.

Dissolved Oxygen. As the free oxygen in a water readily unites with the free ammonia of sewage in the process of oxidation, therefore we should expect the dissolved oxygen to show a drop for each addition of sewage. Plates 32 and 33 show this. In the curve for the averages, Findlay alone fails to show a decrease for the addition of sewage, but this is due to the high supersaturation which from some unknown cause

appeared below Findlay in July. The remaining four curves each show a decrease in the dissolved oxygen due to the sewage of that city. The month showing the increase is the one with the lowest free ammonia below town except November. The remaining supersaturations were, we believe, due to plant growth and were found above Lima, Defiance on the Maumee, and Defiance on the Auglaize in July, and again at the last named station in August. The lowest averages were at Lima, Ft. Wayne and Toledo where the worst sewage pollutions occurred.

BACTERIAL FINDINGS ON MAUMEE WATERSHED.

	July.	August.	September.	October.	November.	Average.
Findlay, above	292	1,110	930	1,436	1,285	1,011
Findlay, below	7,790	3,370	34,960	13,050	1,900	12,214
Lima, above	497	895	3,450	2,910	1,130	1,776
Lima, below	371,300	227,800	94,620	76,760	15,760	157,248
Defiance (Auglaize) above	615	485	3,500	6,070	10,080	4,150
Ft. Wayne, (St. Mary's) above	665	1,550	1,550	1,317	7,360	2,488
Ft. Wayne, (St. Joseph) above	No tak'n	1,260	1,400	813	5,860	2,333
Ft. Wayne, (Maumee) below	145,400	39,040	37,510	7,040	20,080	49,814
Defiance, (Maumee) above	329	838	1,310	1,143	18,300	4,284
Defiance, (Maumee) below	723	6,900	5,720	7,540	22,040	8,585
Napoleon, above	569	210a	575	5,450	7,710	2,903
Napoleon, below	992	4,315	1,100	26,520	16,400	9,865
Toledo, above	270a	250a	195	1,342	7,360	1,883
Toledo, Cherry street	1,030	5,310	4,275	4,250	19,160	6,805
Toledo, Riverside Park	576	220a	4,370	13,600	16,100	6,973

Bacterial Characters. After contemplating some of the complications, shown in the preceding graphical representations of the chemical results, arising from unusual local disturbances, it at least affords a feeling of relief to look upon the simpler bacterial curves for this same river. (Plates 30 and 31.) As is well known the addition of sewage greatly increases the number of bacteria, and thus we look for an upward turn of the curve under the influence of pollution from sewage. Without exception this occurs each month at each city throughout the stream. The amount of the increase is not however constant, but varies with local conditions and rainfall influences. These curves are plotted to the logarithms of the numbers rather than to the numbers themselves, and it should be borne in mind that a small increase on the plate means a much larger increase with the actual number of bacteria. The sewage effects are most noticeable at Findlay, Lima and Ft. Wayne, agreeing

with the chemical findings as shown by the free ammonia determinations. At Defiance the increase is somewhat lessened by the dilution from Tiffin river, whose waters first appear in our samples below Defiance. The bacterial findings of the Maumee and Auglaize rivers as they reach Defiance are nearly the same. The increase at Toledo is not as great as might be surmised would follow from the large number of people having access to the sewers of that city. But the results agree well with the chemical findings. At this city the Maumee is a stream of no small dimensions (at times its volume exceeds 285,000 cubic feet per second—computed from gagings) and this amount of water could receive a large quantity of pollution and show only small increases in the determinations sought. The river at Toledo is greatly affected by the direction and velocity of the wind. With the wind blowing hard from the lake the river water is forced back by water blown in from the lake. We desired to study the effect of such action upon the pollution of the city water supply of Toledo, as the intake is but a short distance up the river. The elements were against us and the wind was blowing from some other direction when we were in Toledo. The nearest approach to a wind favorable to a solution of this problem was in July, and in fact the chemical and bacterial results for that month place the three Toledo stations more nearly on the same level of pollution. We were enabled to approach this question negatively, i. e., by noting the *increase of change* produced in our determinations when the wind blew down the river. Under normal weather conditions and a fair current we would expect little or no pollution at the Toledo intake, considerable pollution at Cherry street, and slightly more at Riverside. We find this state of affairs in the September and October samples bacteriologically, and also chemically, i. e., as far as free ammonia, nitrites and chlorine are concerned. Chemically the same is true in August, but the Riverside bacteriological result is low, due to the count being interfered with. The river runs in a northeasterly course, and accordingly a southwest wind would blow down the river, while a similar effect would result in a lessened degree from a south or a west wind. Through the kindness of the Weather Bureau Observer at Toledo, Mr. W. S. Currier, we append the following table of wind movements on the days of sampling, and for three days preceding. The full effect of the wind upon the water on the day of sampling would not have been attained at the hour the samples were taken:

Date.	Prevailing direction.	Total wind movement.	Maximum velocity and direction.
1898.			
July 20	N. W	244	19 miles W.
" 21	E	257	14 " N. E.
" 22	N. E	192	17 " N. E.
" 23	N. E. and E	187	16 " E.
August 22	S. W	114	12 " S.
" 23	S. W	296	26 " S. W.
" 24	N. W.	150	15 " W.
" 25	W	270	21 " N. W.
September 25	N. W	136	12 " W.
" 26	N. W	273	25 " N. W.
" 27	W	143	12 " N. W.
" 28	E	141	12 " S E.
October 23	S. W	338	20 " S. W.
" 24	S. W	343	29 " S. W.
" 25	S	322	26 " S.
" 26	N. W	356	26 " N. W.
November 11	N. W	208	20 " N. W.
" 12	W	125	9 " S. E.
" 13	W	173	17 " S. W.
" 14	W	280	17 " W.

In October a strong wind had blown for three days with the current. The field note book of the collector records at that time "all of the water has been blown out of the river except in the channel." This caused a good current which carried Toledo pollution away from the Toledo intake, as shown by the analyses. In August and September the effect was somewhat similar, but less marked. A further study of this problem is desirable, but the foregoing facts would indicate that under adverse circumstances Toledo at times receives at the intake a greater or less amount of her own sewage.

The bacterial findings on the Maumee watershed show results from rainfall and consequent soil washings similar to those obtained in the work on other rivers. At such times the number of bacteria was increased as shown above Lima in September and at several places during the wetter months of October and November. The lowest findings were at times of low water, viz: July and August. On the other hand, sewage pollution of the river is so great at certain points resulting in great numbers of bacteria, that the high number of microscopic plants in the soil-washings from a sudden rain is not sufficient to equal the number in the sewage polluted river water and thus at these points a dilution occurs. In other words, wet weather conditions, as below Findlay in September, and below the other larger cities in October and November, yield a lower number of bacteria than dry weather conditions at the same places. Had the acid at Findlay in August been constant, its effect would have

been noticed more. The amount of acid present was not such as to kill the bacteria, but it would have hindered many species from an active multiplication, and thus lower counts would have resulted. As it was the samples were taken too soon after the influx of the acid to show any marked features. A count below Findlay in August, after a hard rain, is consistent with the other results at the same place compared with the weather and the pollution. For some reason, not apparent the number of bacteria is unusually low below Ft. Wayne in October. The St. Mary and St. Joseph for that month also show counts below the average. The lowest results on the watershed were obtained at Findlay, Napoleon and Toledo—those at the last two places being due in part at least to the failure to get an efficient count because of an interference from overspreading growths on the plates. Accordingly these counts are too low, and this should be borne in mind. In addition to these low results of doubtful value there were but three findings in the river water of this watershed, yielding less than 400 bacteria to the c. c., viz.: July above Findlay, July above Defiance on the Maumee, September above Toledo. On the other hand, over 74 per cent. of the tests showed upwards of 1,000 bacteria to the c. c. No data are available to indicate the bacterial purity of the headwaters, as some pollution occurs above each one of our upper stations, and thus we cannot tell whether the water at any time regains its original purity. If it does, then the original bacterial purity could not have been very good, as seen by a study of the table already given. The following table shows better the average condition. Only the above town stations are given. They are supposed to represent the places where the river water is in its most purified state. The first column gives the average of the five months, in the second column (excepting Findlay) is shown the average omitting the month, showing an unusually high number of bacteria due to rain influences. No omission was made at Findlay, as conditions were such that no month gave an exceptionally large number of bacteria:

	Average for five months.	Average for four months.
Findlay above	1,011	1,011
Lima "	1,776	1,358
Defiance, Auglaize, above	4,150	2,668
Ft. Wayne, St. Mary, "	2,488	1,270
Ft. Wayne, St. Joseph, "	2,338	1,158
Defiance, above	4,884	905
Napoleon, "	2 903	1,701
Toledo, "	1,883*	514*

* Low counts due to interference from overspreading growths.

The samples taken from the Maumee river were more closely related to rainfall conditions than those from the Sandusky river, and moreover the Maumee is a deeper stream and less obstructed by dams, consequently its water is not so well aerated and exposed to sunlight as the water of the Sandusky. Under these conditions we find the number of bacteria higher in the stream under discussion than in the preceding one. The number of bacteria as shown by the results obtained is not low enough to make the Maumee water a desirable one for potable purposes.

REPORT ON

SOURCES OF POLLUTION AND PUBLIC WATER SUPPLIES OF THE SANDUSKY AND MAUMEE WATERSHEDS.

By B. H. Flynn, C. E.,

Engineer Ohio State Board of Health.

THE SANDUSKY WATERSHED, INCLUDING SANDUSKY CITY.

GENERAL FEATURES OF THE WATERSHED.

The Sandusky river rises in the western part of Richland county, flows west through Crawford and into Wyandot, then north through Seneca and Sandusky counties and empties into the western end of the Sandusky Bay. The river is 115.5 miles long and has a watershed some 1,581 square miles in area. Its valley is small, having a depth of from 20 to 25 feet and an average width of one-fourth of a mile or less. The bed is usually cut into the limestone or shale for a few feet. The head waters of the river east of Crestline have an elevation of 1,282 feet above sea level or 709 feet above the lake. This gives the river an average fall of 6.14 feet per mile. The Sandusky river consists of several branches until Crestline is reached, but the figure given for the elevation of the head waters is for one branch only. Starting from Crestline with an elevation of 1,155 feet, the average fall of the river per mile is 5.2 feet.

The following table gives the elevations at the different stations, the distance, and the average fall per mile between stations:

Stations.	Elevation above sea level.	Distance between stations in miles.	Average fall per mile between stations.
Head waters	1,282	.....	.....
Crestline	1,155	4½	28.2
Bucyrus	995	16	10.0
Upper Sandusky	835	24	6 7
Tiffin	743	34	5.7
Fremont	618	21	4.3
Lake Erie	573	16	2.5

As seen from this table the river has a good fall, hence a good flow, except below Fremont. Here the Sandusky winds in and out through low, flat, and in many places, marshy land to the Bay; where it spreads out over a broad plain covered with grass and lilies. The water is raised and lowered a foot or more over these plains by the wind, but it is never more than a few feet deep.

Originally the headwaters of the Sandusky were supplied by several springs, 4½ miles east of Crestline, but since these have been appropriated for a public water supply for Crestline, it gets no water from them, especially in summer, and must depend upon the West Branch and upon Stink creek, both of which are supplied to a small extent by spring water and to a much larger extent by the sewage of Crestline.

The river has a number of tributaries, none of which are very large. The principal ones are Broken Sword, Tymochtee, Sycamore, Honey, Wolf, Muskalung and Green creeks, the latter entering the river almost at its mouth.

On the Sandusky river watershed there is an estimated population for 1898 of 100,000; 39,500 of which is in the seven towns of Bucyrus, Carey, Crestline, Fremont, Sycamore, Tiffin and Upper Sandusky; while the remaining 60,500 is scattered through some fifty small villages and isolated houses. The average population per square mile is 63.2, of which 25 3 is urban and 37.9 is rural. These figures are much below the average for the State, and show the watershed to be thinly populated.

The towns mentioned above, except Carey and Sycamore, have more or less complete systems of sewers, all of which empty directly into the Sandusky river. These sewers, however, only carry the sewage of about 13,000 people. These same cities also have public water supplies, all of them using for that purpose at least some of the raw river water. The average daily amount of water pumped from the river is 2,700,000 gallons, which, after being soiled with the cities' waste, is returned to the river as sewage to be pumped out by the next city below and sent through the same course again. In the summer the three upper towns, Crestline, Bucyrus, and Upper Sandusky, use all the river water for the public supply, so that the river below each of these places is practically pure sewage.

Carey has a water supply from wells and is off the Sandusky river also, so it is not influenced by the pollution of the river. Sycamore is also removed from the river and is now putting in a water works which will be supplied by well water.

In examining the river, special attention has been paid to its pollution for ten miles above each water works, in view of the following ordinance:

Section 2433. The jurisdiction of any corporation owning water works, to prevent or punish any pollution of the water, shall extend ten miles beyond the corporation limits. (O. L., 66 v., 209.)

The river has also been examined in and below each town with special reference to any nuisance from the sewage, and also any local contamination of the water supply from the town's own sewage.

DAMS.

Owing to the important bearing of these obstructions upon the ability of a river to supply water and to dispose of sewage, a short description of the dams on the Sandusky river will be given. There are sixteen dams on the river, four of which are used to impound water for a public supply and the rest used mainly to furnish power to grist mills. The following table gives the name, location, use, size, length of back water and pond area of the various dams:

TABLE SHOWING DAMS ON SANDUSKY RIVER.

Number.	Name.	Distance from mouth of river.	Approximate location.	Use.	Width in feet.	Height in feet.	Length of back water in miles.	Pond area in acres.
1	McMickles	96	1½ miles above Bucyrus	Watering stock	60	2.5	3	20
2	Water works	95	Just above Bucyrus	Water supply	50	1.5	1	8
3	Water works	94½	In Bucyrus	" "	70	2.5	0.5	4
4	Gas works	94	" "	Gas works	70	4	0.25	3
5	Water works	70	In Upper Sandusky	Water supply	70	2.5	0.1	0.6
6	Indian Mill	68	Below Upper Sandusky	Grist mill	60	7	1	6
7	St. Johns	45	9 miles above Tiffin	" "	175	8	1	20
8	Water works	38	Just above Tiffin	Water supply	175	5.5	4	80
9	Pioneer Mills	37	In Tiffin	Grist mill	250	7	1	45
10	Spec	36½	" "	" "	225	8	0.8	14
11	Beckley	36	Just below Tiffin	" "	250	4	0.5	15
12	Bakers	34½	2 miles below Tiffin	" "	250	4	"Broken out."	
13	Umsted	32½	3½ miles below Tiffin	" "	200	6	1	25
14	Fort Seneca	28	8 miles below Tiffin	Tile mill	200	5	1	25
15	Ballville	18	2½ miles above Fremont	Grist mill	300	14	1.1	30
16	First Dam	17	1½ miles above Fremont	Electric power	800	14	0.5	15

All the mill dams except the ones at Ballville are of wood construction and in a bad state of preservation. They leak badly all the time, being repaired just enough to keep the mills running. The water works dams are kept in better shape, as all the water has to be utilized in dry weather. The two dams above Fremont are in a good state of preservation and leak but little. At the time of the inspection of this river, July 20, 1898, the water was running 12 inches over the St. John's dam, giving an approximate flow of 525 cubic feet per second, or 341,000,000 gallons per 24 hours.

POLLUTION OF WATERSHED.

Practically all the pollution of the Sandusky watershed is due to the five towns located on the Sandusky river itself. Carey has a water supply and will soon send sewage to Tymochtee creek, but it has but little as yet. Sycamore is just putting in a water works and will soon find sewers necessary. Attica has no sewers as yet, but will soon need them, as it has a public water supply.

Crestline—Population 2,968. This village has the good fortune to be at the upper end of the watershed above all pollution of the river, except that which it sends in itself. Crestline is a railroad town with some manufacturing interests. It has paved streets, electric lights, a water supply and a fair amount of sewers. The water supply is from springs and wells over in Richland county.

Sewage—Crestline is fairly well sewered, two sewers emptying into the West Branch of the Sandusky river and six emptying into "Stink creek," and comprising in all about four miles of sewers. About 70 per cent. of the population have access to the sewers and there are 60 water closets connected to them, but no vaults. The water closets are not used much in summer, every one depending upon outdoor vaults. The vaults are not water-tight and are not regulated by the village in any way.

"Stink creek" as it goes through town is nothing but an open sewer. At the time of inspection, July 19, it was dry above town and supplied entirely by sewage, and this principally from the main hotel It is a very foul smelling, dirty ditch, covered with black scum and all the pools full of filthy sewage mud. In hot, sultry weather the ditch can be smelled all over town and causes a terrible nuisance. Filth of all kinds is thrown into the stream, and many open privies are built directly over it or so close that every rain will wash their contents into the ditch. It also drains two cemeteries which lie just east of town over in Richland county. Below the sewers the creek is a succession of small pools and is overgrown with weeds and bushes. This causes the appearance of the

stream to rapidly improve, so that about a mile from the last sewer the stream has no smell and is comparatively clear.

The West Branch is in good condition above town, and it is claimed, never goes dry; but as it was only a few inches deep at the time of inspection, it can dispose of but little sewage. This creek only receives two sewers and as these have but few connections, the stream is in much better shape than the other one. Below each sewer there is some deposit and the water is black, greasy and covered with scum, but four hundred yards below the last sewer the sewage is not visible.

These two creeks unite about a mile from town and form the Sandusky river. The river at this point winds slowly through a flat clay bottom land, and has no smell and but little sediment and this is not offensive.

Wells—Nearly every house has a private well and these are used to a large extent for domestic purposes. The dug wells are from 20 to 30 feet deep and only go into the drift. There are three private drilled wells which furnish good water. These are 100 feet deep and go through the drift and shale into the sandstone.

Bucyrus—Population 8,516. This town has paved streets, electric lights, a public water supply and a sewer system. It has nothing but general manufacturing, being supported mainly by the country around it. The water supply is from the Sandusky river.

Sewage—The city is well sewered, fully ninety per cent. of the population having access to the some eight miles of sewers. There are about three hundred water closets and three hundred vaults connected to the sewers. As shown on the map, the sewers empty at the most convenient point into the Sandusky river. The first sewer below the water works has but few connections and the river above the small mud dam at the brewery is in fair shape. But starting with the sewer from the brewery, the river as far down as the cemetery is an open sewer, each tributary sewer adding more filth before the river has had time to recover from the last one. The small dam opposite the brewery is to back the water up so that it can be pumped to the adjacent ice pond. At this time, owing to the recent rains, this dam was allowing some water to escape, which helped to dilute the brewery sewage, but did not prevent the river from being covered with a thick, black scum and giving of a horrible stench. From this point down the river is a succession of stagnant pools with their bottoms covered with a foot or more of thick, black mud that constantly gives off bubbles of gas. The water is black, greasy and covered with a

thick black slime. It is claimed that the river is in good condition now and that it becomes much worse when there is no rain.

The gas works dam is used to impound water for washing the gas and condensing purposes. The refuse of the gas plant is discharged above this dam. It consists of naphtha, grease and lamp black. The quantity is not large, but it discolors the river badly. Just below this dam the main sewer enters, and as the dam held all the water notwithstanding the recent rains, the river from this point was pure sewage. Night-soil is buried in shallow trenches near the river, below town, and every hard rain washes some of it into that stream. Kitchen garbage, hog pens, geese, slaughter houses, all combine to make the river at this point one of the worst in the State.

Vaults are required to be water-tight and 50 feet from wells. All the old ones violate the first part of this regulation, however.

Wells—Well water and filtered cistern water are used entirely for drinking purposes, as the public water supply is not recognized as fit for domestic use. Most of the private wells are dug, and from 20 to 30 feet deep, going through the soil and gravel down to hard-pan. In the south-eastern portion of the city, the wells go through a shale into gravel and the water comes to the surface. It is claimed that there is enough water in this section to supply the whole town. There are about a dozen drove wells in use. These extend into the hard-pan for a few feet.

Upper Sandusky—Population 3,597. This village has electric lights, a water supply, some sewers, but no paved streets. The public water supply is from the Sandusky river. It is a quiet country village with not much manufacturing. The surface drainage and sewerage is to the Sandusky river and to small ditches emptying into that river.

Sewage—The town has but an average sewer system, some seventy-five per cent. of the population having access to it. There are 5.2 miles of sewers with five outlets direct to the river and two to ditches. There are 104 closets and eight vaults connected to the sewers. Fifty of these closets are in the schools and jail. The large west side sewer empties into Juvenals run, which would be dry a greater part of the time were it not for the sewage. It is badly overgrown with weeds so that it holds the sewage until it decays, causing considerable nuisance. The river below town was not in bad shape at the time of inspection, July 13, but it is said to go nearly dry and then smell from the sewage.

Wells—There are about two hundred dug wells in town, which are used for domestic purposes. These are from 10 to 20 feet in depth and only go through the sand and gravel to the hard-pan, thus getting all surface water. There are about twenty drove wells. These go through the hard-pan to the limestone which lies about 65 feet below the surface.

Carey—Population 2,000. Carey has a public water supply and electric lights but no sewers or paved streets. The water supply is from wells west of town. There are but few manufacturing plants in the village.

Sewage—The surface drainage is to Spring run, then to Tymochtee creek which joins the Sandusky river 57 miles from its mouth. Carey is eight miles by water from the Sandusky river. About twelve houses have cesspools draining to Spring run through private sewers. All others use outdoor vaults. Even this small amount of sewage causes the run to become a nuisance in summer. It gets full of weeds and has to be cleaned out and flushed each year.

Vaults are constructed in any suitable manner, but must be 100 feet from wells. Slaughtering is done near Spring run, but the refuse is hauled away. Quite a number of hogs are kept within the corporation limits.

Wells—The private wells are mostly drilled, but only from 6 to 20 feet deep, getting their water just above or in the limestone.

Sycamore—Population 1,500. This village has electric lights, but no sewers or paved streets. At the time of inspection a water supply was just being introduced. The water is to be pumped by an air lift from two wells, each six inches in diameter and 200 feet deep to a receiving well. The water will then be pumped to an elevated tank by a Snider-Hughes pump of 500,000 gallons capacity. There are four miles of mains in, with fire plugs attached, but no domestic services have been put in as yet.

The surface drainage is to Sycamore creek, which joins the Sandusky fifty-one miles from the mouth of the latter. Sewers will soon be necessary. Now every one depends upon shallow vaults and, in many cases, mere pits.

Tiffin—Population 13,900. This city has nearly all the modern improvements required, electric cars and lights, paved streets, sewers and a water supply. The water is taken from the Sandusky river and from wells. The principal industries are two glass works, a pottery, three or four large machine and agricultural works, a door and sash factory, a small woolen mill and two breweries.

Sewage—The accompanying map shows the locations of the sewers and their outlets. There are eight miles of sewers with 10 outlets to the Sandusky river and one to Rock creek. Some 80 per cent. of the population have access to the sewers, and there are some 450 vaults and water closets connected. An ordinance requires vaults to be made water-tight, but does not limit their distance from wells. All the old vaults are not

water-tight, usually being boarded up only. There are quite a number of dry earth closets in use.

The Pioneer Mill dam at the foot of Webster street backs the water up to the water works, so that the whole river in front of the city is back water. Into this back water is dumped all the sewage of the city. When the river is low this back water is very foul, it is covered with scum and gives off pretty strong odors, while the river bottom is overlaid with a thick layer of black sewage mud. When the dam is full the large quantity of water seems to hide the sewage for a time, but if the mill did not use the water, and it was compelled to stand for any length of time, the sewage would soon make the river unbearable. As it is, the water collects for a time and gets saturated with sewage, it is then turned down the river and the empty bed is left the putrefy and smell in the sun until more water comes down and fills it up again. A large pulp mill formerly turned its waste into the river, but this has been shut down for some time past. As shown on the map, there are 12 slaughter houses and two breweries that turn their refuse into the river. A distillery and woolen mill also add their waste products to the river's fund of impurities.

Wells—When the river is muddy, well water is used almost entirely for domestic purposes. This water is principally from shallow dug wells, which only go to the limestone, some 16 feet down. All the new wells are drilled into the rock and get a fair water. Filtered cistern water is drunk to some extent.

Fremont—Population 6,236. This city, the county seat of Seneca county, is a very pretty residence place and has considerable manufacturing also. It is the head of the navigation on the Sandusky river, though but few boats come up now.

Sewage—The surface drainage and sewerage is direct to the Sandusky river. There are about 16.5 miles of sewers, with four outlets to the river and giving about 75 per cent. of the population access to them. The sewers empty directly into the Sandusky at the most convenient point, except those of the west side, which empty into an intercepting sewer, running along the west bank of the river and provided with storm overflows to the latter. No record is kept of the sewer connections and no one would even venture an estimate as to the number, but it cannot be large, from the common use of outdoor vaults. An ordinance requires that all vaults shall be 50 feet from a well, unless they be water-tight, and this is required now. All the old vaults are not tight, usually only having plank sides, and some times not even that.

When the river is low the sewage causes considerable nuisance. The river becomes covered with a green scum, smells some and the bottom has considerable sediment. This is especially true around the mouth of

the intercepting sewer. When the wind is up the river, it raises the level of the water a foot or more, but it probably never blows the sewage up past the water works on account of the old dam some distance below the intake.

Wells—The city water, when clear, is used for domestic purposes by fully two-thirds of the people, but when muddy nearly every one resorts to private well water. This water is obtained principally from dug wells, there being only some 20 drilled wells in use. The dug wells go to the bed rock, which is 16 feet below the surface near the river, and 45 below further back on the hills. The drilled wells are from 50 to 75 feet deep and go through the clay, hard-pan and gravel into the rock.

Sandusky has been included in this group, but as its sewage bears no relation to the pollution of the watershed but does bear on its own water supply, it will be taken up in connection with that subject.

PUBLIC WATER SUPPLIES.

There are seven towns on this watershed that have public water supplies. Two only, Bucyrus and Upper Sandusky, use nothing but river water, though Fremont and Tiffin depend mainly upon the river. Fremont has galleries and wells to help out, while Tiffin has wells. Crestline uses spring and well water. Carey uses well water, and Sycamore will in time be using well water. Sandusky which is grouped with this watershed uses the Bay water. Attica uses a well and gallery supply.

Surface Water Supplies.

Bucyrus—Population 8,516. The water works was put in by a private company in 1883 and has cost to date something over $75,000. The company operating the water works does so under a franchise granted in 1895. It previously worked under one granted in 1883. The following paragraph, from the last ordinance, specifies the kind of water to be supplied:

"Said, 'The Bucyrus Water Company,' further agrees that it will construct within the period of eight (8) months, a reservoir, having a capacity of not less than 60,000,000 gallons and located at a point suitable and near to and in connection with the pipe distribution of said Company.

"It is mutually agreed that the water with which said reservoir shall be filled, from which the water supply is to be carried into the system of distributing pipes of said company, is to be taken from the running waters of the Sandusky river, and shall be settled and filtered before being forced into the pipes for distribution for domestic use; and when so filtered, it shall be considered suitable for the requirements of this contract."

The present source of supply is the Sandusky river. The only possible source of pollution to the river within 10 miles is Knisely springs. This is a picnic ground about eight miles from Bucyrus and one-half mile back from the river. It has no sewage, but the surface drainage is direct to the river. Of course the most serious danger to the Bucyrus water is the village of Crestline 16 miles from the intake by river. The river water above the water works is not in good condition. It is covered with scum in many places and has a greasy, murky appearance.

Owing to the small amount of water flowing in the river in summer, it is necessary to store a little water to tide over dry spells. The water company has a small dam one-half mile above the intake, which will hold back when full about 2,000,000 gallons. At the water works there is another dam which backs the water up over the intake pipe. This dam also retains something over 2,000,000 gallons. No attempt is made to protect these reservoirs, boys swim in them, barn yards drain to them, and hogs and cattle have access to them.

The company has purchased land for the reservoirs required in the franchise, but has not even started to build them as yet. When the works were first put in, the water was taken from a well near the river, but this soon failed and direct connection had to be made to the river, which is now the sole source. The river at the intake has a drainage area of 94 square miles.

The old supply well, now serving as a pump well, is 50 feet in diameter and 30 feet deep, and is connected to the river by a 16-inch pipe; the water stands 13 feet deep in the well or at the level of the river above the dam. It is covered with a conical board roof and no trouble is experienced from growths. It was cleaned in 1892, but only a small quantity of mud was removed as the suction of the smaller pump is right on the bottom of the well and keeps it fairly clean.

Direct pressure is furnished by two pumps, both put in in 1883 and in fair condition now. One is a compound duplex Holly pump of 1,500,000 gallons capacity and the other is a compound duplex Walker pump of 1,000,000 gallons capacity.

Before reaching the mains, the water passes through two Hyatt pressure filters erected in 1886. They are the old style vertical filter, 10 feet in diameter and contain $2\frac{1}{2}$ feet of crushed granite and $1\frac{1}{2}$ feet of coke. The filters are washed from once in two days to twice a day, as the condition of the water requires. This is done by reversing the flow of water through the filter, and is not assisted by any mechanical stirrer. Sulphate of alumina is used when "necessary," which means hardly ever. Only 11,700 pounds or about 30 barrels were used last year. The strength of the coagulant solution is varied according to the muddiness of the

water. In case of fire, the filters are cut out. A couple of years ago the filters were cleaned out and a lot of rubbish, dead animals, etc., removed.

There are 12 miles of mains in, which give some 70 per cent. of the population access to the water. There are 500 services in, of which 325 are in use and 175 of these metered. The average daily consumption is 691,000 gallons, which, reduced 10 per cent. for slip of pumps, would be 622,000 gallons. Owing to leakage at the filters and to wash water, the average daily consumption is not over 550,000 gallons. The average daily consumption per consumer is 280 gallons, but this does not mean much here, as the water is not used for domestic purposes at all.

The yearly water rates are as follows:

Private house, five rooms or less	$1 25
Each additional room	25
Private bath tubs, each	1 00
Private water closets, each	1 00
Private stables, per stall	75

Meter rates per 1,000 gallons:

Below 1,000 gallons per day	25
5,000 to 10,000 gallons per day	10
Above 10,000	08

Upper Sandusky—Population, 3,597. The water works is owned by a private company operating under a franchise granted in 1889, when the works were first built. The plant has cost to date about $70,000. The city may purchase ten years from April 23, 1889, and every five years thereafter. The franchise contains the following clause regarding the kind of water to be supplied:

"The source from which the supply of water shall be obtained is from wells sunk in the gravel banks of the Sandusky river or river water dispossessed of earthy matter by settling pools.

"The wells are to be so constructed and protected that no surface or unfiltered river water shall enter them, the intention being to obtain a pure and wholesome supply from a subterranean strata of gravel.

"These wells shall be increased from time to time as the wants of said village demand, and the source shall always be protected from pollution and contamination.

"A separate suction pipe may be run to the river to be used in cases of great emergency only."

The supply is taken at present direct from the Sandusky river at a point just above the city. The river at this point has a drainage area of about 285 square miles. Above the intake the river flows through rolling land, much of it being in pasture, which gives hogs and cattle free

access to the water. For the first few miles the river flows over a mud and gravel bottom, but above this the limestone outcrops and forms most of the bed. There are no villages to pollute the water within the 10-mile limit, the greatest danger being from the sewage of Bucyrus, 24 miles distant. About a mile and a half above the water works is a collection of large springs. It is claimed that in summer these springs supply the river entirely, and that no water flows above them, but inspection showed a small amount of water coming down the river. Two miles above the intake a small run brings in the drainage of the principal cemetery of the town. It is three-fourths of a mile from the river.

At the water works the river is backed up by a small dam forming an impounding reservoir of about 500,000 gallons capacity. From this pond the intake pipe leads to a filter box, but usually the water passes direct to the pump well without filtering. It is claimed that the direct connection to the river is used only when the latter is clear, and that when the river is high and muddy, the water is pumped to a large reservoir, allowed to stand a certain length of time, then passed to the filter box and filtered, then allowed to flow to the pump well. This storage reservoir is 325 feet long by 180 wide, and will hold 2,288,000 gallons. It has earthen embankments and floor, with no riprap or paving. It is protected from surface drainage by a ditch running along the crest of the hill above it. The reservoir was only built in 1895 and has not been cleaned since and no trouble is experienced from growths.

The filter box is 11 by 20 feet and contains three feet of fine gravel. It is used to filter the water from the reservoir only, and acts as a strainer merely. It is cleaned about once a month by scraping off the top layer and twice a year by removing and washing all the gravel.

The pump well is 85 feet in diameter at the top and 12 feet deep, with sides paved with rough stone. Originally this well supplied the town with ground water, but it soon failed and direct communication had to be made to the river. Some ground water is probably still supplied by it.

Two Blake pumps of 1,500,000 gallons capacity each are used to pump the water to the standpipe. These pumps were put in during 1889, and are in but fair condition at present. One pump working 14 to 16 hours per day is enough to supply the town. This would give an average daily consumption of 325,000 gallons for the summer or an average of 250,000 gallons the year round. No records whatever are kept of the pumps and the above figures are estimated only.

The standpipe was built in 1889 and is in bad shape now. It consists of a wooden tank 24 feet high and 28 feet in diameter, holding 95,000 gallons, and placed on a circular brick tower 75 feet high. The water

mains cover practically the whole town, only 30 houses not having access to them. There are 456 services in, but only 350 of these in use, 11 of which are metered. Although one-half of the people have the public water in their houses or yards, it is estimated that fully 75 per cent. of the total population drink well or spring water. The average daily consumption per consumer is 110 gallons.

The annual water rates are as follows:

Private house, five rooms or less	$5 00
Each additional room	1 00
Private water closets, each	2 00
Private bath tubs, each	1 00
Private stable, one horse and carriage	3 00

Meter rates per 1,000 gallons:

One thousand gallons or less per day	25
Over 5,000 gallons	10

River and Wells.

Tiffin—Population 13,900. The water works is owned by a private company operating under a franchise granted December 1, 1879, and extending for 25 years. It contains no provision for purchasing works by the city and has the following clause regarding the water:

"That there is hereby given and granted to the 'Tiffin Water Works,' their associates, successors or assigns, the exclusive right and privilege for the period of 25 years from and after the date of the passage of this ordinance, of supplying the city of Tiffin, Ohio, and the citizens thereof, with water to be taken from such points and in such manner as will best subserve the object and purposes of said 'Tiffin Water-Works,' their associates, successors or assigns, in complying with the objects and requirements herein enumerated."

Nothing whatever is said regarding the kind or purity of the water to be supplied.

The supply at present is taken from the Sandusky river and from wells. There is nothing to pollute the river for 10 miles above the intake, except, perhaps, a picnic grounds a little ways up the river. These grounds are not much used now, but two dirty vaults still stand on he river bank. Tiffin is 34 miles by river below Upper Sandusky, which is the nearest serious source of sewage pollution.

About 400 yards above the water works a dam impounds water for the city supply and also to furnish power to run the pumps for a part of the time, usually all night. The intake is just above the dam, the pipe leading to a small reservoir from which the water is pumped. There are seven drilled wells along the river bank which are pumped directly to the

mains. These wells are from 200 to 268 feet deep, with a 10-inch casing; and they are located 200 to 300 feet apart, extending up and down the river valley. The suction from the pumps is connected directly to the casing and the water is lowered 24 feet during pumping hours. The water is hard but of good quality otherwise. The water is found in the Onondago limestone which outcrops in this locality.

The company claims that these wells supply all the city water except in cases of emergency, but these cases happen nearly every summer afternoon, when the river water is turned into the mains to help out. They also claim that they intend to improve the method of pumping the wells so that no river water need be used at all.

Direct pressure is furnished by three pumps, all made by the Holly Manufacturing Co. One pump of 1,500,000 gallons capacity was put in in 1879, and is run by water power. A steam pump of 3,000,000 gallons capacity was put in about 1882, and another of 4,000,000 gallons capacity was erected in 1895. The average daily consumption is 900,000 gallons. This is only the estimate of the engineer, as no better figure could be obtained. The average daily consumption per consumer is 165 gallons. There are 26 miles of mains, giving about 75 per cent. of the population access to the water. There are 1,275 services in, of which only 900 are in use and 100 of these metered.

The meter rates are 30 cents per 1,000 gallons and 15 cents for the largest consumer. The flat rates seem to vary with the amount of influence the consumer has with the council. There are no definite fixed rates.

River and Gallery.

Fremont—Population 6,236. The water works was put in by the city in 1883 and has cost to date $160 490.

The supply is from the Sandusky river, wells and galleries. The river at the water works has a drainage area of 1,280 square miles. The only sources of pollution to the river within 10 miles are the small villages of Fort Seneca and Ballville. The first place is a small station just 10 miles above the intake. Ballville has some 300 inhabitants and is situated on the river bank, so that all its surface drainage goes direct to the same. It has no sewerage.

The river water is admitted by three 10-inch pipes to a reservoir excavated in the solid rock below the river level. This reservoir is also supplied to some extent by three lines of from six to nine-inch vitrified tile, with a total length of 1.5 miles, which are laid in the gravel beds by the side of the river. The reservoir is 200 feet long by 150 feet wide and the water stands six to eight feet deep in it usually, or at the river level

giving a capacity of from 1.4 to 1.8 million gallons' The reservoir is open, but its banks are carefully paved, and no trouble is experienced from growths or scum. It is cleaned of sand and mud by pumping out the water and raising the sediment in buckets, as the basin is too low for flushing. At the side of the reservoir is the pump well, 25 feet in diameter and 20 feet deep, and connected to the former by one 24-inch pipe.

There are five wells 10 inches in diameter and 300 feet deep. They were put in during the fall of 1897 and supply about 230,000 gallons per day. The wells are 300 feet apart and extend up and down the river bank. The machinery for pumping the wells is inadequate, and they can probably supply more water with better machinery, although the water is lowered 40, 50, 70, 75 and 125 feet in the five wells respectively.

The water is pumped to a standpipe by two Knowles' pumps, one a 3,000,000-gallon compound condensing duplex and the other a 1,000,000-gallon duplex. The standpipe located in the center of the city is 100 feet high and 25 feet in diameter, giving a capacity of 365,000 gallons. There are 10 miles of mains in with 856 services in, of which 720 are in use and 10 of these metered. About 75 per cent. of the total population have access to the water. The average daily consumption is 1,600,000 gallons and the average per consumer is 350 gallons. This is an enormous figure, and must be explained by the extravagant use of water in public fountains, watering troughs and for flushing sewers, and by the habit of allowing the water to run continually when it is muddy.

The yearly water rates are as follows:

Private house, six rooms or less	$5 00
Each additional room	50
Private water closets, each	2 00
Private bath tubs, each	3 00
Private stable, one horse and carriage	2 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	25
Over 4,000 gallons per day	10

Well Supply.

Carey—Population 2,000. The water work was put in by the village in 1894 and has cost to date $28,500. The supply is from five wells, 50 to 60 feet deep and 5⅝ inches in diameter. The wells obtain their water in the limestone, which lies 14 feet below the surface. When the wells are not being pumped the water is within 13 feet of the surface and ordinary pumping only lowers it about a foot.

The water is pumped direct from the wells to a standpipe by two horizontal, compound, duplex, Laidlow-Dunn-Gordon pumps of 500,000 gallons capacity each. The standpipe is 16 feet in diameter, 115 feet high and has a capacity of 173,000 gallons. There are four miles of mains, giving 80 per cent. of the population access to the water. There are 125 services in use, of which four are metered. The average daily consumption is 100,000 gallons, and the average per consumer is 130 gallons.

The annual water rates are as follows:

Private house, including street sprinkling	$6 00
Private bath tube, each	2 50
Private water closets, each	3 00
Private stable, one horse and carriage	2 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	30
One thousand to 2,000 gallons per day	23
Four thousand or more gallons per day	15

Well and Spring.

Crestline—Population 2,968. The water works was put in by the village in 1871 and has cost to date about $205,000. The operating expenses for 1897-98 were $2,488. The supply is obtained from wells and springs 4½ miles east of the village. Two reservoirs have been built, one in 1871, holding 1,295,000 gallons, and one in 1888, and holding somewhat more than the first one. The second one is not in use at the present time. Not more than 3½ square miles of territory are tributary to these reservoirs, and some of this drainage is diverted by ditches around the reservoirs. Springs in the bottom and along the sides of the first reservoir supplied the town until 1895, when three wells were drilled. These wells are 140, 170 and 180 feet deep and the water flows from them freely. A 20-day test of the wells only lowered the water 22 feet, and shortly after the pumping stopped the wells began to flow again. The three wells supply 150,000 gallons per day by their natural flow, but have to be pumped about 48 hours a week to keep up the supply. This pumping is done by a three-quarter million Worthington compound pump, which was put in in 1896. The wells flow and are pumped to the first reservoir, which is 127 feet above the streets, and supplies the mains by gravity. The reservoir in use is formed by throwing earthern embankments across the ends of a ravine. Neither the bottom nor the sides are paved or ripraped. The bottom is covered with a foot or more of black mud and dead moss, and this covered with a thick layer of living moss.

When stirred, the mud gives off bubbles of gas which have a very disagreeable odor. The superintendent is trying to get the reservoir cleaned, paved and covered, which would remove the only objectionable feature of the Crestline water-works.

The water flows to the village through an 8-inch wooden pipe line, four and one-half miles long, but this furnishes an inadequate supply, especially in case of fire. The water seems to reach the mains clear and tasteless, but it must sooner or later be affected by the bad condition of the reservoir.

There are 10 miles of mains in, giving some 90 per cent. of the people access to the water. There are 370 services, of which 308 are in use, and 65 of these metered. The average daily consumption is 275,000 gallons and the average per consumer is 150 gallons.

The annual water rates are as follows:

Private house, 4 rooms or less	$3 50
Private house, 5 rooms	4 00
Each additional room	25
Private water closets, each	3 00
Private bath tubs, each	2 00
Private stable, one horse and carriage	2 00

Meter rates per 1,000 gallons:

From 1 to 10,000 gallons per year	40
From 10,000 to 500,000 gallons per year	12

Well and Gallery.

Attica—Population 729. Although this village has a public water supply, it is as yet bears no relation to the pollution of the watershed. As soon as the water supply is generally introduced, sewers will become necessary and some means of disposing of the sewage then found. The surface drainage is to Honey creek, to which the sewers would naturally lead. There are no sewers or drains in use now, the storm water being carried off in ditches. No water closets have been put in, everyone depending upon the outdoor vault.

Water Supply—The water works were put in by the village in 1895, and have cost to date about $17,147. The supply is from a large well and collecting gallery. The well is 28 feet in diameter and 25 feet deep. It is built of brick and covered with a conical board roof. The water is found in a bed of gravel which begins eight feet below the surface. In this gravel is laid 300 feet of 8-inch tile, which carries the ground water to the well by gravity. The well and gallery have so far supplied sufficient water. The site of the water works is at present removed from all local pollution.

The water is pumped to a standpipe by a Gordon pump of 500,000 gallons capacity, operated by a Hicks gasoline engine. The standpipe consists of a tank 20 feet in diameter and 25 feet height, with a capacity of 59,000 gallons, placed on a brick tower 40 feet high. The tank was cleaned in 1898 for the first time and a quantity of sediment removed. There are two and one-half miles of mains in, which give some 95 per cent. of the population access to the water. There are 63 services in, 61 of which are in use and 30 of these metered. The average daily consumption is 13 500 gallons, and the average for each consumer is 40 gallons.

The annual water rates are as follows:

Yard hydrant for one family	$3 00

No baths or water closets in use.

Meter rates per 1,000 gallons:

Less than 500 gallons per day	20
500 to 1,000 gallons per day	15
Over 3,000 gallons per day	06

Where the public water is on the premises it is generally used for domestic purposes.

The private water supply is from dug wells 20 to 25 feet in depth. These wells obtain their water from a bed of gravel and quicksand. As the ground is very porous and vaults are covered over when full, the ground water cannot help but be polluted.

Sandusky. Although Sandusky is not on the Sandusky river watershed, it can very properly be considered in this group. Sandusky has an estimated population of 20,888 for 1898, but the city claims 22,000 or more.

Sewage—The combined system of sewers is used, with some 31¼ miles in place, and 16 outlets to the Sandusky bay. There are 760 water closets and vaults connected to the sewers, representing the sewage of about 5,000 people. More than 75 per cent. of the population has access to the sewers. There are about 10 dry earth closets in use, all the rest of the houses using vaults, except those sewered, of course. All new vaults must be constructed of brick, stone or plank, and be as water-tight as possible, and none shall be less than 25 feet from any well or cistern. The sewage never seems to cause any nuisance, but as will be mentioned below, it may pollute the public water supply.

Water Supply—The water works was put in by the city in 1876 and has cost to date $572,603. The supply is from the Sandusky bay through an intake crib east of the city as shown on the map. Of course the bay water cannot be in first-class condition after receiving all the sewage brought down by the Sandusky river, but the source of this pollution is

at least 35 miles distant and the dilution is so great that it can have but little if any influence.

The most serious source of danger to the water is the sewage of Sandusky itself. As shown on the map there seems to be two main currents in the bay, one going out past Johnson's Island and the other sweeping up past the city docks and out past Cedar Point. As the sewage of the city empties into the bay along the whole water front this second current carries all the city sewage. If the wind is blowing to the southeast, this current will be carried over to the intake crib and the city run very good chance of drinking sewage polluted water.

The intake crib is connected to the pump well by 1,800 feet of three-foot brick conduit, through which the water flows by gravity to a pump well. The intake is 1,200 feet from the shore line. The water is pumped from the receiving well to a standpipe, or direct in case of fire, by two Worthington pumps. One of 3,000,000 gallons capacity was put in in 1876 and the other of 7,500,000 gallons capacity in 1890.

The standpipe is 180 feet high and 25 feet in diameter, giving a capacity of 662,000 gallons. There are 40.4 miles of mains giving practically every one access to the water. There are 2,873 services in, of which 462 are metered.

The average daily consumption is 3,633,800 gallons which reduced 5 per cent. for slip and leakage would make the daily average 3,450,000 gallons. The average per consumer is 200 gallons and for the whole city the per capita consumption is 165 gallons, showing the almost universal use of the city water.

The yearly water rates are as follows:

Private house, five rooms or less	$5 00
Each additional room	1 00
Private water closets, each	2 50
Private bath tubs, each	3 00
Private stable, one horse and carriage	3 00

The meter rates are six cents per 1,000 gallons with certain minimum charges for the different sized meters.

No private wells are allowed in the thickly settled portion of the city and the only well water used comes from some 40 dug wells in the outskirts. These wells only go to the limestone, which is not more than five to 10 feet below the surface. Spring and filtered cistern water are drunk to a limited extent.

Thus it is seen that it is very important that Sandusky should have a pure water supply, as it is the only city in the whole group whose inhabitants must depend almost entirely upon the public water supply. Besides

the danger from sewage pollution, the bay water is objectionable on account of its muddiness after every storm. As the average depth of the Sandusky bay is only seven or eight feet, every high wind stirs up the bottom completely and makes the water very muddy.

The following table gives a summary of both the water supply and sewage of the seven principal towns of the group:

SANDUSKY WATERSHED.

	Water supply.													
	Estimated population for 1898.	Source of water supply.	Method of supplying water.	Ownership of water works.	Date of installation of water works.	Cost of plant to date.	Miles of mains.	Per cent. of population having access to mains.	Number of services in use.	Number of meters.	Average daily consumption in gallons.	Average daily consumption in gallons per consumer.	Total pumping capacity.	Filters.
Bucyrus	8,516	Sandusky river	Pumping direct	Private	1888	$75,000	12	70	325	175	550,000	280	2,500,000	Hyatt pressure.
Carey	2,000	Wells	Pumping to standpipe.	Village	1894	28,500	4	80	125	4	100,000	180	1,000,000	None.
Crestline	2,962	Springs and wells	Gravity from reservoir	Village	1871	205,000	10	90	308	65	275,000	150	750,000	None.
Fremont	6,286	Sandusky river, galleries and wells	Pumping to standpipe.	City	1883	160,000	10	75	720	10	1,600,000	350	4,000,000	None.
Sandusky	20,888	Sandusky bay	Pumping to standpipe.	City	1876	572,603	40.4	98	2,878	462	3,450,000	200	10,500,000	None.
Tiffin	13,900	Sandusky R. and wells	Pumping direct	Private	1879	?	26	75	900	100	900,000	165	8,500,000	None.
Upper Sandusky	3,597	Sandusky river	Pumping to tank.	Private	1889	70,000	11	95	350	11	250,000	110	3,000,000	Small sand box.
Totals	60,099			8 private		$1,111,103	118.4		5,601	827	7,125,000		30,250,000	
			Total	4 public										
Averages	8,585				1882	185,184	16.2	88	800	118	1,018,000	184	4,321,400	

SANDUSKY WATERSHED—Concluded.

	Sewage.								
	Outlet of sewers and drains.	Number of outlets.	Is sewage a nuisance?	Does sewage cause pollution of local water supply?	Miles of sewers.	Per cent. of population having access to sewers.	Number of closet and vault connections	Population using sewers.
Bucyrus	Sandusky river	6	Yes	No	8.1	90	600	4,000
Carey	Spring run		"	"			*12	75
Crestline	Stink creek and west branch Sandusky	6—2	"	"	4	70	60	400
Fremont	Sandusky river	4	"	"	16 5	75		
Sandusky	Sandusky bay	16	No	Yes	31.2	75	760	4,900
Tiffin	Sandusky river	11	Yes	No	8	80	450	2,800
Upper Sandusky	Sandusky river	7	"	"	5.2	75	112	700
Totals		52	Total { 6 Yes, 1 No.	{ 6 No, 1 Yes	78		1,994	12,775
Averages		9			12	78	332	2,129

* Private sewers.

THE MAUMEE WATERSHED.

TERRITORY INCLUDED.

The Maumee watershed comprises the northwest corner of Ohio with adjacent portions of Indiana and Michigan. It has a total area of 6,344 square miles, of which Ohio has 4,702, Indiana 1,303 and Michigan 339. In Ohio the watershed contains all of Williams, Defiance, Paulding, Van Wert and Allen, and parts of Mercer, Auglaize, Shelby, Hardin, Hancock, Wyandot, Seneca, Putnam, Henry and Fulton counties. In Indiana it includes parts of Steuben, De Kalb, Noble, Allen, Wells and Adams counties; in Michigan only parts of Hillsdale and Lenowee counties. The southern part of the watershed is very flat, the broad plains being broken only by the gentle rises of the glacial moraines, and by the river valleys. The northern part of the watershed is not quite so level, the moraines are higher and the valleys deeper.

This whole region was at one time well covered with hard wood forests, but now all the heavy timber has been used up and the fields are gradually being cleared, though there are thousands of acres still left with their old stumps, brush and small timber just as the lumberman left them after taking out the best pieces.

On the cleared land corn is the chief crop especially in the southern part. Farther north the stock and dairy interests are large.

DRAINAGE.

The Maumee river flows northeast through the center of the watershed and empties into the western end of Lake Erie. Its principal tributaries are the St. Joseph and Tiffin rivers from the north, and the St. Mary and Auglaize rivers from the south. The St. Mary and St. Joseph rivers unite at Fort Wayne and form the Maumee river from there down, while the Tiffin and Auglaize rivers enter the Maumee at Defiance, giving the watershed a leaf or fan-shaped appearance. The Auglaize river has two quite large tributaries, the Ottawa and Blanchard rivers which enter it from the east.

The whole territory has been glaciated and the tributaries follow the depressions between the moraines while the Maumee has cut across them. In glacial time Lake Erie extended as far as Fort Wayne, covering a large portion of the Maumee valley and the outlet of the lake was through the Wabash river. Then the ice moved out of the St. Lawrence basin and gave the lake a lower outlet to the east. This caused all the territory tributary to the old lake to drain into the Maumee river which occupied

the bed of the now vanished lake. The St. Mary and St. Joseph rivers formerly emptied into Lake Erie near its outlet to the Wabash. Then when the water was lowered they had the choice of flowing to the Wabash or doubling back into the old bed of the lake. Some peculiarity of slope made it easier to turn to the eastward than to continue their old course to the Wabash.

The territory drained by the Auglaize and St. Mary rivers is extremely flat and the drainage is poor, leaving the ground wet or even swampy in places. For successful cultivation all this land must be carefully ditched and tiled, which is now being done to a large extent. When this land was well wooded and no ditches cut, the streams must have had a very uniform flow throughout the year. Even at the present time with the forests cut away and the whole country ditched, the flow is remarkably uniform owing to the extreme levelness of the country.

North of the Maumee the country drained by the Tiffin and St. Joseph rivers is more hilly and the flow is kept up by the large number of springs. The ditches are supplied with "fountain water," in the language of the section.

The Maumee river has a length of 150 miles in which there is a fall of 164 feet, or an average of 1.1 feet per mile. This is a very small fall and makes the stream very sluggish. The Auglaize river has a length of 74 miles with a fall of 4.4 per mile, giving it one of the best currents in the watershed. It drains an area of 2,504 square miles.

The St. Mary river is 100 miles long, has an average fall of 2.38 feet per mile and drains an area of 784 square miles. In Indiana its fall is very much below the average, making its current there very slow.

The St. Joseph river has an average fall of 3.13 feet in its 100 miles of length and a watershed of 1,132 square miles. Just the reverse of the St. Mary, its greatest fall is in Indiana where it is utilized by three mills.

The Tiffin river has a length of about 65 miles with an average fall of 4.5 feet per mile and drains 669 square miles of territory.

POPULATION ON WATERSHEDS.

In estimating the population on the watersheds the census of 1890 is used for the rural population, and the estimated populations for 1899 for all the larger cities and towns. This makes the total population approximately correct, as the rural population changes but little if any.

In Indiana and Michigan the populations for the towns could not be closely estimated, but the best figures obtainable were used.

The total population on the Maumee watershed is 612,206, of which 456,794 is in Ohio, 136,271 in Indiana and 19,141 in Michigan. As the

total area is 6,344 square miles, the average density per square mile is 96.5. This includes rural and urban population.

A separation of the total population into urban and rural has been made, though but little value can be given the figures, except as they may show where pollution may be expected. All cities and villages with an estimated population of 1,000 or over for 1899 are classed as urban. This small figure was chosen so as to include in the urban population all villages that would have any sewage, or should have any. There are a large number of villages just within this class that have no sewerage but are just beginning to feel the need of some; and there are quite a number that have a fair proportion of sewage. If a larger figure were chosen there would be a number of villages classed as rural that have some sewage. The intention is to keep out of the rural population all villages, the inhabitants of which pollute the streams to which they drain more than the same number of isolated farm houses.

The total rural population on the watershed is 281,133 or an average density of 44.3. In Ohio alone this figure is 43.8, in Indiana 46.6 and for Michigan 42.2, showing considerable uniformity in the distribution of the rural population throughout the watershed in the different states. The urban populations are not so evenly distributed, the average per square mile in Ohio being 53.3, for Indiana 57.9 and for Michigan only 14.3, while the average for the whole watershed is 52.2.

In order to show the area of the various watersheds in the different states, the distribution of the total population in all the subdivisions, and the average population per square mile in all the divisions, the following tables have been prepared:

TABLE I—AREAS OF WATERSHEDS IN SQUARE MILES.

	Ohio.	Indiana.	Michigan.	Totals.
St. Mary river	427.54	356.08	.....	783.62
St. Joseph river	225.46	662 87	243.96	1,132.29
Auglaize river	2,370.56	133 07	.....	2,503.63
Tiffin river	574.16	.....	94.87	669.03
*Maumee river	1,903 96	151.55	.....	1,255.51
Maumee watershed	4,701.68	1,303.57	338.83	6,344.08

* Maumee river includes only the direct drainage to the river itself. Blanchard river drainage area — 924.47 square miles. Drainage area below Toledo water works — 1013 square miles.

TABLE II—Populations on Watersheds.

	Ohio.			Indiana.			Michigan.			Totals.		
	Rural.	Urban.	Total.		Urban.	Total.	Rural	Urban.	Total.	Rural.	Urban.	Total.
St. Mary river	18,268	6,300	24,568	22,160	3,595	25,755	.....	.....	.....	40,428	9,895	50,353
St. Joseph river	9,277	3,170	12,447	26,755	9,521	36,276	10,000	.....	10,000	46,032	12,691	58,723
Auglaize river	105,292	83,183	188,475	3,020	1,200	4,220	.....	.....	.....	108,312	84,383	192,695
Tiffin river	23,409	6 503	29 912	.....	.....	.....	4,800	4,841	9,141	27,709	11,344	39,053
Maumee river	49,832	151,560	201,392	8,820	61,200	70,020	.....	.....	.....	58,652	212,760	271,412
Maumee watershed	206,078	250,716	456,794	60,755	75,516	136,271	14,800	4,841	19 141	281,133	331,073	612,206

Population on watershed below Toledo water works Rural, 5,175; Urban, 126,000; total, 131,175.

TABLE III—Average Population per Square Mile.

	Ohio.			Indiana.			Michigan.			Totals.		
	Rural.	Urban.	Total.	Rural.	Urban.	Total.	Rural.	Urban.	Total.	Rural.	Urban.	Total.
St. Mary river	42.8	14.8	57.5	62.2	10.1	72.8	.....	.....	.....	51.6	12.6	64.2
St Joseph river	41 2	14.1	55.8	40.8	14.4	54.7	41.0	.....	41.0	40.7	11.2	51.9
Auglaize river	44.4	35.1	79.5	22.7	9.0	31.7	.....	.....	.....	43.2	33.7	76.9
Tiffin river	40.8	11.3	52.1	.....	.....	.....	45 3	50.9	96.2	41.4	17.0	58.4
Maumee river	45.1	137.3	182.4	5.8	40.2	46.0	.....	.....	.....	46.7	169.4	216.1
Maumee watershed	43.8	53.3	97.1	46.6	57.9	104.5	42.2	14 2	56 4	44.3	52.2	96.5

Table No. 1 shows the area of the four principal tributaries in the three states, also the areas draining to the Maumee river direct, without first entering one of the large tributaries, while the totals represent the whole Maumee watershed.

Table No. 2 shows the distribution of the rural, urban and total populations on the various watersheds in the different states.

Table No. 3 shows the average population per square mile, urban, rural and total on the different divisions. This table is merely a combination of Nos. 1 and 2.

The total population for the Maumee watershed includes Toledo and the population drained by Swan creek. As this drainage enters the Maumee below the Toledo water works intake, it could very properly be excluded from the total watershed. The Maumee at Toledo is hopelessly polluted, and any addition will cause no harm, except as it pollutes the lake. No public water supply is endangered by the pollution. The total area of the watershed below the Toledo water works is 101.1 square miles, and has a rural population of 5,175 and an urban population of 126,000, or a total of 131,175. This would affect the average urban population considerably and should be borne in mind when referring to those figures. The average urban would drop from 52.2 to 32.8 per square mile.

These figures on the populations have been given to show where pollution is most liable, the more densely populated districts being more liable to pollution. A dense rural population is dangerous on any watershed, the run-off from which is used for a public supply. The average farm yard usually contains a manure pile, a hog pen and an outhouse, sometimes provided with a vault but frequently not, so that every rain washes the accumulated filth to the nearest water course. The pollution is not large and might not show in a chemical or bacteriological analysis, but just such isolated houses may spread any infectious water-borne disease which the inmates may have. And such diseases are prevalent in these houses due to the poor location and unsanitary condition of the wells.

POLLUTION.

In reporting on the specific pollution due to city sewage, objectionable manufacturing, etc., the Maumee river will be followed from its source up, noting all causes of pollution and bringing in each tributary watershed in the proper order. No attention will be paid here to the pollution of the river below the Toledo water works, as it bears no relation to public water supply and during the present order of things never will. No city or town will ever attempt to use Lake Erie near the mouth of the Maumee for a water supply. From the water works down the

Maumee seems to be dedicated to the public as an open sewer, and will probably continue so to be.

The public water supplies of all cities and towns will be described at the end of this report so as to make them more accessible and not to burden the body of the report.

SOURCES OF POLLUTION.

Lucas County Childrens' Home—Above the Toledo water works the first thing to pollute the Maumee is the Lucas County Children's Home. The institution has 110 inmates besides the officers and help. It has a water supply from the Erie canal and a complete sewer system discharging directly to the Maumee. There are eight cows, two horses and any number of hogs kept on the farm on the river bank. Any epidemic in this home would seriously endanger the Toledo water supply, which is taken from the river about five miles below.

Club Houses—For several miles above Toledo there are a number of club houses and fishing places which send considerable filth to the river especially during the summer season.

Perrysburg—Population 1,600. This village is on the east bank of the Maumee and sends its surface drainage to that river and to a creek which enters the river some miles below. There are no sanitary sewers in town or any objectionable manufacturing and the only pollution is from dirty streets and yards.

Maumee—Population 1,532. Maumee is just above and across the river from Perrysburg. It has no sanitary sewers and sends surface drainage only to the Maumee river and to the canal which passes through the town. It is quite a business town and will soon find sewers necessary. Both Perrysburg and Maumee have a few houses with private sewers to the river.

Grand Rapids—There is a state dam located at this village to feed the Miami and Erie canal. It is 1,610 feet long with a height of 5½ feet and backs the Maumee river up 19 miles, a little past Napoleon.

Bad Creek—This creek enters the Maumee 36 miles from its mouth. Bad creek drains Colton, Delta, Siney and Winameg, all classed as rural except Delta.

Delta—Population 1,451. Nearly all the streets of this village are tiled and some of these are used as sewers, carrying the drainage from kitchen sinks, a few vaults and three closets to Bad creek, which enters the river 12 miles away. This small amount of sewage from about 30 persons only, seems to cause no local nuisance. Along Bad creek are located an ashery, cheese factory and a large saw mill. These cause some nuisance from

dumping refuse into the creek. The saw mill increases the organic matter with its piles of decaying sawdust. The ashery is in operation only in summer. It reduces wood ashes for potash and soda. The surface drainage is pretty bad from the filthy condition of the yards and alleys.

There are no regulations regarding the construction of vaults and they are built to suit owner, which means poorly built. Night-soil is generally hauled to the country, but some is buried on the premises.

Most of the private wells are drilled and from 80 to 90 feet deep, with some surface wells 12 feet deep. Some of the deep wells flow, in fact, the whole country is full of springs which keep up the summer flow of the creeks to a remarkable degree.

Creameries—Bad creek drains a grass country and small creameries are very numerous on its head waters. Some of these cause a local nuisance, unless the refuse is fed to hogs, and hog pens are not considered a nuisance.

South Turkey Foot Creek—This creek enters the Maumee and is 37 miles above the outlet. It drains the villages of Malinta, Hamler, Ridgeland, New Bavaria, Pleasant Bend and Holgate, all of which, except Holgate, are considered rural. These small villages may have a saw mill, a tile mill or grist mill, but they seem to add no more pollution to the stream than would a similar population on isolated farms. Hamler has a creamery draining to the creek.

Holgate—Population 1,500. This is a dull, spread-out village, with no paved streets, electric lights, water supply or sewers and not much business. The town site is very flat and poorly drained. The street drains empty into Brush creek, a branch of Turkey Foot. There are no vault or closet connections to the sewer.

Vaults are required to be built of brick or plank, but regulations are not enforced. A few dry earth closets are in use. Night-soil is hauled to the country. The industries consist of a grist mill, creamery and two stave factories. The creamery runs the year round and causes a nuisance in the summer from the decaying refuse, which is run to a hole in the ground. The slaughter houses are north of town, no killing being allowed within the corporation.

The wells are all driven and from 80 to 130 feet deep. The water is obtained just above or in the rock which lies at the above depth.

North Turkey Foot Creek—This creek drains a small watershed on which there are only the villages of Beta, Liberty Center and the town of Wauseon. It enters the Maumee river just opposite South Turkey Foot.

Wauseon—Population 2,210. This town is the county seat of Fulton county and has a public water supply from wells south of town, electric lights and sewers, but no paved streets.

There are 5¼ miles of tiling, almost all of which is used as sanitary sewers. These sewers empty both north and south into ditches which empty into Turkey Foot. The sewers give about 60 per cent. of the population access to them, but a much larger per cent. have drains for surface water only. There are 54 closets connected directly with the sewers and a few closets running to cesspools which are connected with the sewers, in all, the sewage from some four hundred and fifty people is carried to the creek. Owing to the large number of springs flowing to the ditches, the sewage causes but little nuisance except in the driest weather, then it is necessary to clean out and flush the ditches.

There are no vault regulations, a number of people having holes in the ground, which are covered when full, and some have no pretense of a vault. Most of the night-soil is buried in the country.

The industries consist of a grist mill, saw mill, two tile works and a creamery. The latter is on the ditch north of town and discharges all its refuse into same. It is too far removed to cause complaint, but it is very foul during dry weather.

Most of the private wells are drilled into the rock from five to 30 feet, and as the rock is from 165 to 180 feet down, the wells are quite deep. There are still left a few surface wells, these being about 35 feet deep.

(The public water supply is described at the end of the report)

Henry County Infirmary—A small run entering the Maumee just below Napoleon brings in the surface drainage from this institution. The buildings are old and have no sewer system. There are 50 inmates, attendants and the usual amount of stock on the place.

Napoleon—Population 2,543. This town is the county seat of Henry county and is situated on both sides of the Maumee river and about 35 miles from its mouth. The Miami and Erie canal also runs through the town. It has a public water supply from the Maumee river, paved streets, electric lights and some sewers. The town is kept up mainly by the fact that it is the county seat.

Both the sewers and surface drainage go to the canal and river. There are 2.8 miles of sewers with two outlets to the river and one to the canal. The upper outlet to the river is but a few rods below the water works intake, and as this point is in the back water of the Grand Rapids dam, there is great danger of contamination of Napoleon's water supply from its own sewage. The current in the river is very slight and can easily be influenced by the wind.

There are not more than 50 connections to the sewers, representing about 300 people. Owing to the large amount of water, the sewage causes no nuisance, except perhaps that flowing to the canal, which to-

gether with dirty surface water, causes some local complaint in hot weather.

Vaults are required to be water-tight, and must be 50 feet from wells. Quite a number of vaults are not so constructed, especially the old ones.

The river water is not much drunk, nearly every one using private well water. These wells are nearly all dug, and 25 feet or less in depth. A few drove wells get their water on top of the shale, about 60 feet down.

State Dam—Thirteen miles above Napoleon and five below Defiance, is a State dam to divert part of the Maumee to the canal. It is 400 feet long, 7 feet high, with flash boards 1 foot high, and backs the water up into Defiance.

Defiance—Population 9,759. It is the county seat of Defiance county, and is situated at the junction of the Tiffin and Auglaize with the Maumee river. The surface drainage of the city is to all three rivers, but the sewers empty into the Maumee and Auglaize rivers only. The Miami and Erie canal also passes through the city and receives some of the surface drainage. Defiance has a great deal of street paving, electric lights, water supply, and at one time had street cars. Its water works is owned by a private company, and the water is taken direct from the Maumee just above the entrance of the Tiffin river.

There are 11.93 miles of sewers, giving some 60 per cent. of the population access to them. The sewers empty into the rivers at the most convenient place; 12 going to the Maumee and five to the Auglaize, also a ditch which empties into the latter river. There are about 250 connections to the sewers, which send the sewage of some 1,500 people direct to the river. A few vaults and cesspools are connected to the sewers also, but they are not allowed.

There are no vault regulations, and the vaults are poorly constructed. This is very bad, as the hydrant water is not drunk at all, and the city depends entirely upon surface well water. The wells are shallow, only 8 to 30 feet deep, getting the water in a bed of gravel just under the surface soil.

The principal industries are hoop and heading factories, carriage and wagon shops, strawboard works, woolen mills and a stove foundry. The woolen mill and strawboard works discharge their refuse into the canal, which joins the river here.

Auglaize River—This river brings in the drainage of Ada, Bluffton, Columbus Grove, Continental, Delphos, Dunkirk, Findlay, Forest, Lima, Ottawa, Paulding, Payne, Spencerville, Van Wert and Wapakoneta, all of which are considered as urban; also any number of small villages that are classed as rural.

Continental—Population 1,500. This village has a public water supply from wells, and electric lights, but no paved streets or adequate sewer systen. The storm drains empty into Powell creek and Blanchard river. There are several closets connected with the drains to Powell creek. The village has no health officer and every thing is in very poor condition. Vaults are filled and covered with dirt, slaughtering is done in town, and offal is fed to hogs, many of which are kept within the corporation. There are but few private wells in town, nearly every one using the hydrant water. The few wells are drove and go to the rock 40 feet down.

Flat Rock Creek—This is the second creek bringing urban drainage to enter the Auglaize river. On this watershed are the towns of Paulding and Payne in Ohio, and Monroeville in Indiana, together with several small villages.

Paulding—Population 1,900. This village is the county seat of Paulding county. It is situated on Flat Rock creek and nine miles from where it enters the Auglaize river.

Paulding has paved streets, electric lights, but no public water supply or sanitary sewers. Many of the streets are sewered to the creek, but for storm water only, no closets or vaults being allowed to connect. Notwithstanding this, there are a few cesspools in town with connections to the storm sewers, one from the hotel causes considerable nuisance in the summer. The jail has flush closets sewered to the creek, and the school house has a cesspool which drains there also. Thus a variable population is sewered to the creek, depending upon the number of inmates in jail, and also if the school is in session or not. During the summer the sewage of not more than 50 people enters the creek.

There are no vaults in town, the box system being used almost entirely. Night-soil is buried just northeast of town and near the creek.

The town has no industries beyond the tile and saw mills.

Private wells are nearly all drove and drilled, getting their water a few feet down in the limestone which lies 30 feet below the surface.

Paulding County Infirmary—This institution is two miles northeast of Paulding, near Flat Rock creek. It is an old place, with no modern improvements, and has some 54 inmates.

Payne—Population 1,500. This town is on Flat Rock creek, 12 miles by water above Paulding. It has no paved streets, electric lights, water works or sewer system. The town site is very flat, and the streets have to be well tiled to carry off the surface water. These drains empty into Flat Rock, which gets all the surface water of the town. Closets and vaults are not allowed on the sewers and none were found. Most of the

drains are too shallow to drain the cellars, and none of these conveniences are used, as the ground water is very near the surface.

It is estimated that one-fourth of the town use boxes in the outhouses, the rest having vaults. Night-soil is buried west of town. There is some slaughtering done in town which has caused a nuisance.

The industries are several saw mills, tile mill and an ashery. The latter runs only in the summer.

Monroeville, Indiana—Population 1,200. This town is 12 miles above Payne on Flat Rock, to which all its drainage goes. It has no sanitary sewers or closets connected with the drains.

Little Auglaize River—This river joins the Auglaize 20 miles above the mouth of the latter at Defiance. It drains nearly all of Van Wert county and part of Paulding. The only town that can be classed as urban in this whole district is Van Wert, all the rest being small villages, supported by the country around and a few tile and stave mills. Nearly all the timber has been cut away and the lumber interests are dead. This has stopped the growth of the villages, and in some cases nearly depopulated them.

Van Wert—Population 7,000. This town, the county seat of Van Wert county, has paved streets, electric lights, a public water supply from wells, but a poor sewer system. In fact nearly all the sanitary sewers are semi-private affairs. In all there are 4.2 miles of sewers. This includes public and private. These have 13 outlets to Town creek, which runs through the city, and have some 60 closets connected with them, and carry to the creek the sewage of some 400 people, as one sewer is from the hotel.

All water closets that are connected with the sewers or with the sewer itself must have cesspools. This keeps all the solid matter out of the creek and prevents deposit of sewage in its bed. The sewers cause a nuisance in the summer when the creek goes dry, and their outlets have to be limed to make the creek bearable. There are a number of vaults that are drained by the sewers; in fact a town ordinance requires that all vaults be so drained, unless said vaults are water-tight. Most of the vaults are water-tight and kept cleaned out. Night-soil is taken to the city dump and buried. This dump is one mile southwest of town and drains to Maddox creek, a branch of the Little Auglaize river.

The private well supply is from shallow dug and drove wells principally; these wells are 16 to 24 feet deep, and get their water in a bed of quicksand just below the clay soil. A few drilled wells go to the rock.

The manufacturing products are pianos, potash, doors and sashes, carriages, wood work, oil well supplies, tiling, etc. None of these seem to cause any nuisance.

Van Wert County Infirmary—This institution is four miles east of Van Wert, near Dog creek, a branch of the Little Auglaize. It has a water supply and a sewerage system, the latter going through a small ditch to Dog creek. There are usually about 30 inmates at the place.

Blanchard River—This stream enters the Auglaize river from the east and 24 miles above Defiance. It has a watershed of 124 square miles and drains nearly all of Hancock and parts of Hardin, Allen and Putnam counties. On its watershed are located the towns of Bluffton, Dunkirk, Findlay, Forest and Ottawa, with the usual array of small villages.

Ottawa—Population 1,978. This town is the county seat of Putnam county. It has paved streets, electric lights, but no water supply or adequate sewer system. The town is located on the north bank of the Blanchard river and south of Towe run, its surface drainage and sewage going to both.

All public sewers are for storm water only and house connections are not allowed, though it is said that a few have slipped connections in. There are several private sewers with one or two connections each emptying into the river, three of these emptying into the "Swale," an old channel of the river. This "Swale" is full of stagnant water, and the sewage and the wash water from a steam laundry cause it to become a nuisance in summer. A saw mill on the banks of this place has drained the mouth of it so as to have water for its work and the water in the "Swale" is never changed except during high water when the river clears it out. This old river bed is a menace to the health of the community, and should be filled up or cleaned out and drained.

The court house and jail have private sewers to Towe run, which enters the river just west of town. In all, the sewage of about 150 people finds its way to the river.

Vaults must be water-tight and 50 feet from a well; but these regulations are not enforced, and vaults are constructed to suit the owner. There are a few dry earth closets in use. Night-soil was formerly buried in a dump just west of town, but the lease has expired and it is now buried anywhere.

On the east side of town nearly all the private wells are drilled from 50 to 190 feet deep and strike the rock from 40 to 90 feet down. The west side wells are dug from 10 to 20 feet deep and find their water in a sand vein.

The industries consist of wheel and spoke factories and two creameries. All these are on the banks of the river and send their waste directly into it. Quite a number of hogs are kept within the corporation limits, being tolerated until complained against.

Putnam County Infirmary—This institution is five miles northeast of Ottawa. It has a water supply from a 90-foot drove well, and pumped to tanks by wind engines. There are three water closets in the building and three outdoor vaults, all connected to an 18-inch sewer, which empties into a ditch three-fourths of a mile away, and this empties into the Blanchard river one-half mile below. There are 52 inmates in the place, which is a fair average.

Bluffton—Population 1,400. About three miles above Ottawa the Big Reilley creek brings in the drainage from Bluffton, some 15 miles up the creek. This town has a public water supply from wells. It has electric lights but no sewers or paved streets.

Quite a number of the streets are tiled to the creek, but no connections are supposed to be made with the drains. One of the hotels, however, has a drain from the vaults to these storm sewers. There are about 10 water closets in town which have private sewers to the creek. Vaults are required to be 75 feet from wells, but the regulation is not enforced. Vaults are usually built of stone or brick, but not water-tight; quite a number of boxes are used. Night-soil is removed to any convenient place.

Most of the private wells are drilled a few feet into the rock, which lies from 12 to 20 feet below the surface. The industries consist of a few saw and grist mills, also a creamery, but that is not running now.

Findlay—Population 20,000. Findlay, the county seat of Hancock county, lies on both sides of the Blanchard river and 40 miles from its mouth or junction with the Auglaize. The town has paved streets, electric lights, street cars, a fair sewer system and a public water supply from the Blanchard river.

The surface drainage and sewers go to Eagle creek and Blanchard river. A small run entering the river on the north drains part of the the town. There are 12.2 miles of sewers, giving about 50 per cent. of the population access to them. With these nearly 500 water closets and vaults are connected, representing about 3,000 people. The sewers have four outlets to Eagle creek, and five to Blanchard river. The sewage entering the river seems to cause but little nuisance, but that going to Eagle creek causes a good deal of trouble during low water. The creek goes nearly dry in summer, and the sewage collects in the pools where it decays, causing very foul odors. A greater part of the year the creek does not contain water enough to carry off the sewage deposits, and this leaves the bottom of the creek covered with a filthy black mud. One sewer with about 30 connections, empties into an old quarry near the T. & O. C. tracks. This pond has no outlet, but the sewage causes no

nuisance, as the water seems to be changed through underground ch nels. The greatest objection to this as a dumping place for sewage is the danger of the contamination of the ground water.

Vaults are not water-tight, and are constructed to suit the owner. They must be cleaned at least yearly, and the night-soil taken to the country and buried. There are quite a number of dry earth closets in use. Garbage is cremated, as is also a little night-soil.

The private well water is drunk a good deal, especially when the river water is muddy or the reservoir is low and the water smells. These wells are both drove and dug, the water being obtained for both kinds in or just above the rock, which varies from on the surface to 30 feet below it.

A glycerine factory northeast of the city, sends its waste, principally sulphuric acid, to the Blanchard river through a combined ditch and sewer, which enters the river just below the water works dam. Another glycerine factory was found to send some refuse to the river above the water works, polluting the public water supply.

The principal manufacturing establishments are a glass works, potteries, nail works, wood working shops, etc. There is also a brewery which sends its waste direct to the river through a short sewer. There is a grist mill 2½ miles below town, which uses water power furnished by the Blanchard river. Its dam is 200 feet long and 5 feet high, backing the water up into the city.

Forest—Population 1,267. This town has electric lights, but no paved streets, sewers or public water supply. The drainage is north to a swamp drained by the Blanchard river and south direct to the same river. There are a number of tile drains in town, but not enough to carry off the surface water. During heavy rains the sewers back the water up and flood the few cellars drained by them. There are no closets or vaults connected with the sewers. The old vaults in town are planked or in some cases mere holes in the ground, but the new ones must all be brick, or boxes have to be used. Night-soil is hauled to the nearby farms.

Most of the private wells are drove to the limestone, 70 to 80 feet down, then drilled a few feet into it. The rock is overlaid by a thick layer of blue clay.

A creamery in town has a connection for waste water to the storm drain which empties direct to the river. This creamery runs the year round, and the drains become a nuisance in hot weather. In fact the ditches and drains all give trouble in summer unless carefully cleaned out, owing to their very flat grade. The one slaughter house is outside of the village, its offals are fed to hogs.

The only industry in town is a steel roofing plant, employing about 30 men.

Dunkirk—Population 1,143. This town has no paved streets, water works or adequate sewer system. The drainage goes to "Shalley," and this to the Cessna branch of the Blanchard river. The streets are well tiled and the drainage good. The ground water is low here owing to a large quarry, 20 feet deep, just southeast of town. There are no closets or vaults connected with the drains.

Vaults are constructed in any way to suit the owner, brick, plank, boxes or none at all. Night soil is hauled to the farms.

Most of the wells are drilled from 30 to 80 feet deep, entering the limestone eight feet below the surface. There are no surface wells, as it is necessary to go below the quarry level to get water.

There are a great many hogs kept in town and no objection is made to them unless they are complained against. The industries consist of a grist mill, saw mills and planing mill.

Ottawa River—This river joins the Auglaize about 29 miles above Defiance. It drains parts of Putnam, Allen and Hardin counties, with the towns of Ada, Columbus Grove and Lima.

Columbus Grove—Population 1,982. This town has electric lights, but no paved streets, water works or adequate sewerage. Its surface drainage is to Plum creek into which the principal street tiles empty. These sewers drain the streets, cellars and kitchen sinks, but no water closets. The opera house and a few dwellings have private sewers to the creek but the total population sewered will not exceed 50. It is estimated that one-half of the town use boxes, the rest plank vaults. Night-soil is hauled to farms.

One half of the people in the village use surface wells not more than 10 feet deep, the water coming from a bed of quicksand. It is claimed that the other half is supplied by 15 drilled wells which are 115 feet deep and strike the limestone 30 feet down.

Hogs are allowed in town if no complaint is made. Slaughtering is done along Plum creek and offals fed to hogs.

The industries consist of the manufacture of staves, heads, brooms, tile and the packing and shipping of chickens. This is done in town and causes a good deal of trouble in preventing a nuisance.

Lima—Population 31,000. Lima is the county seat of Allen county and the next to the largest city in the northwestern part of the State. It has many miles of paved streets, electric lights, good street car service, a public water supply and a fair sewer system. The public water supply is

from wells and a small creek east of town, not influenced by the city sewage.

Lima has about 25 miles of sewers, combined system, with 18 outlets direct to the Ottawa river and 10 to small ditches that flow to the river. About 75 per cent. of the city's population has access to the sewers and there are 2,500 connections with them, or the sewage of some 15,000 people enters the river. Below the city the Ottawa river is very foul and dirty and gives off a horrible stench. Part of this nuisance was caused by the effluent of a paper mill, which has burned down since the inspection. Formerly the river was very filthy within the city limits but it has been straightened and deepened so that all the sewage is carried below and most of the nuisance is abated within the city.

There are a large number of vaults within the city, very few of which are water-tight. It is estimated, however, that three-fourths of the outdoor closets are of the dry earth pattern. Night-soil and garbage is buried on the city dump grounds.

Most of the private wells are drilled, going into the rock which is but a few feet down. There are still a few shallow surface wells in use.

There are quite a number of ponds within the city limits, some of these being old abandoned quarries. There are two parks which have quite large lakes for pleasure purposes, these are filled by surface water. A large refinery has reservoirs for its own water supply. These small bodies of water, with the exception of those which are too small to be permanent, drying up in the summer, seem to cause no nuisance.

Lima has several railroad shops, machine shops, car works, iron works, flour mills, a tannery, etc.

Allen County Children's Home—This institution is three miles southeast of Lima. It has a complete sewer system, with an outlet to the Ottawa river. It has about 70 inmates.

Allen County Infirmary—This place is two miles east of Lima, on the Ottawa river, to which it is sewered. It has about 75 inmates.

Ada—Population 2,415. Ada is a college town with a permanent population as above, and a floating student population of about 1,500. Its drainage is to two runs which empty into "Hog" creek or the Ottawa river. There are 2½ miles of sewers and a number of drains which empty into the uns above mentioned. No closets or vaults are allowed on the sewers, which are used for storm water and cellar drainage only. A few kitchen sinks are connected, and it is claimed a few vaults are also drained to them.

Vaults are constructed in any way to suit the owner, usually of plank or brick. Night-soil is hauled to farms outside of the town. Garbage is fed to hogs in the village.

The drains cover the place pretty well and keep the ground dry, but they are not adequate for heavy storms. Both of the small runs and Hog creek are dry in the summer and sewage could not be emptied into them without some treatment beforehand. Hog creek is now being deepened and straightened to drain Hog creek marsh east of town.

One-half of the private wells are drilled into the rock, which is 20 to 24 feet down. The rest are dug wells, which get their water on top of the rock.

The industries consist of a flour mill, turning and planing mill and a machine shop.

It must be noted that none of the college buildings have water closets, depending upon outdoor vaults entirely.

Delphos—Population 4,100. This town, lying both in Van Wert and Allen counties, has paved streets, electric lights, a water works, but not enough sewers. The water supply is from drilled wells just southeast of town.

Its drainage is to Jennings creek, to Flat Rock creek, a branch of the above, and to the Miami and Erie canal, which passes through the center of town. Jennings creek joins the Auglaize river 36 miles from Defiance. The town is fairly well sewered to both of the above creeks, five outlets to Jennings and three to Flat Rock. Only one of these sewers, the Main street sewer, emptying into Jennings creek, has any closet connections. This sewer runs the length of Main street, the business street of town, and has about 10 water closets connected with it. The paper mill north of the town also runs its wastes to this sewer. It is claimed that this sewer causes no nuisance, but from the size of the creek and from the amount of sewage it must be objectionable during low water unless the canal aqueduct leaks enough to keep it flushed out. The rest of the sewers are for storm water only and have no closet or vault connections. Any kind of a vault is used and none are water-tight. Night-soil is hauled to the country and buried.

Private wells are not used much. The few in use are mostly drilled into the limestone, 12 to 14 feet below the surface, and are from 60 to 70 feet deep. A few wells get the surface water above the rock.

A brewery discharges its waste through a private sewer to Flat Rock, and makes it so offensive that in dry weather the creek has to be flushed from the canal.

The industries of the town are wheel and handle factories, planing mill, paper mill, brewery, grist mill and small railroad shops.

Wapakoneta—Population 4,000. This town, the county seat of Auglaize county, is situated on the Auglaize river 64 miles from its mouth. It has paved streets, electric lights, a public water supply, but no sewer system. The water supply is from wells in the northeastern part of town.

The storm water drains empty into the Auglaize river, which passes through the town. There are not supposed to be any closets connected with these, but it is said a few are and the outlets of same would indicate it. The jail, court house and two schools have closets which are sewered to the river. Also quite a number of private houses have sewers to the river and a number of vaults are built close to the river bank, so that every rain washes the contents into the river. In all some 250 people are sewered to the river, besides the varying population of the jail and some one thousand school children. During dry weather the river gets very low and the sewage accumulates, causing a nuisance. As the construction of vaults is not regulated, none of them are water-tight. Night-soil is hauled to the farms.

Private wells are both dug and drove, but all are only from 14 to 35 feet deep, obtaining their water in a bed of gravel at the river level.

The industries are a handle factory, machine shop, furniture factory, churn factory and bottling works. The latter has a sewer to the river.

Auglaize County Infirmary—This institution has about 50 inmates, and is north of Wapakoneta and back from the river. It has no sewerage system and depends upon outdoor vaults.

The head waters of the Auglaize river are badly polluted by waste from the oil fields.

Tiffin River—This river enters the Maumee from the north and about a mile-and-a-half above the outlet of the Auglaize river, both rivers joining the Maumee within the city limits of Defiance.

The Tiffin river drains parts of the counties of Henry, Defiance, Fulton and Williams in Ohio and a small portion of Lenawee county, Michigan. The only towns on its watershed classed as urban are Bryan, Stryker and West Unity in Ohio and Hudson and Morenci in Michigan. Its rural population is up to the average and made up of a well-to-do class of people, engaged in dairying and stock raising to a large extent.

Bryan—Population 3,176. This town, the county seat of Williams county, has electric lights, a public water supply, but no paved streets or adequate sewer system. The water supply is from wells in the southeastern part of town. The drainage of Bryan is to two runs which empty

into Beaver creek a branch of the Tiffin river. The streets are well tiled and drained for storm water, except for the heaviest rains, then they are not large enough and cellars are flooded. These drains are not supposed to carry sewage, but about 10 closets and five cesspools have been connected with them. The northern part of the town is drained to a county ditch and the southern part to Lynn run. These join just west of town and go to Beaver creek. These ditches are supplied to a large extent by spring water and the small amount of sewage seems to cause no nuisance. Even the local brewery and creamery, which drain to Lynn run, have not been complained of.

Vaults are not water-tight, and are built of stone, brick or plank to suit. Night-soil is hauled to a dump one and one-half miles west of town near Lick creek.

There are only a few surface wells in town, most of the wells being drove and from 90 to 140 feet deep. Many of the deep wells are artesian, as are the wells for the public water supply.

The industries of the town are the creamery and brewery above mentioned, a grist mill, agricultural works, brick and tile works, wheelbarrow works, planing mill and two large hay barns.

Stryker—Population 1,017. This spread-out country village has no paved streets, electric lights, sewers or public water supply. Its drainage is west to the Tiffin river about one-half mile away. Nearly all the streets are tiled, but no closets or vaults are connected with these. Vaults are supposed to be water-tight, but most of them are planked only. Night-soil is buried west of town.

There are no surface wells in town. All are drove and from 115 to 135 feet deep. These wells get their water in shale lying above the limestone. The industries of the town are hoop, stave and oar factories, lumber yards and a tile mill.

West Unity—This town claims 1,000 people, but hardly has it. It is on Leatherwood creek, a branch of the Tiffin river above Stryker. Its streets are drained to the creek, but there are no sanitary sewers. The wells are all shallow, getting the surface water only. The industries are a woolen mill, creamery, grist mill and wood working.

Morenci, Michigan—Population 2,665. This town has no sewers or water supply, but it is situated directly on the Tiffin river, and all of its surface drainage goes to that stream.

Hudson, Michigan—Population 2,176. This village has a public water supply and about two miles of sanitary sewers which empty into the Tiffin river. There are 132 water closets in use, representing the sewage of about 800 people. It is claimed that the sewage causes no nuisance.

Hicksville--Population 3,569. This town is on the head waters of Gordon creek, which enters the Maumee 76 miles from its mouth at the bay. It has electric lights, a public water supply from wells, but no paved streets or adequate sewer system.

There is over a mile of tiling going to Mill creek, a branch of Gordon, which is used for storm water, cellar drainage and kitchen sinks only, though one closet is said to be connected. There are but few vaults, and these are comparatively tight; most of the outhouses have no vaults whatever. Night-soil is dumped on a farm west of town near Mill creek. The private wells are principally drilled or bored and from 25 to to 130 feet deep, going through the surface soil and clay, finding water in a deep bed of gravel. There are still a few dug wells in use. Many of the deep wells are artesian and furnish an excellent water. The town has practically no industries outside of a hoop factory.

Antwerp—Population 1,383. This town is right on the bank of the Maumee and 90 miles from its mouth. It has no paved streets, water supply or sewers. There are a few tiles laid to the river and ditches for storm water, but no closets are connected. Vaults are merely holes in the ground, which, when full, are covered over and new ones dug. Some of the night-soil is buried in the low lands near the river. The private wells are driven to the rock, which is 40 to 50 feet down. Still a few dug wells in use; these are only 16 to 18 feet deep. The old abandoned Wabash canal is not yet filled up and causes a nuisance in the summer on account of the rubbish thrown into it. Hogs are kept in town and some of the pens are in bad shape. The slaughtering is done west of town on the Maumee river.

The only industries in town are the usual saw, grist and tile mills.

Fort Wayne, Indiana—Population 50,000. This town is situated at the point where the St. Mary and St. Joseph rivers join to form the Maumee river. It has all the modern improvements of a city, with a good water supply and a fair sewer system. Its sewers are accessible to to 60 per cent. of the people, and fully 50 per cent. of these have connections. This gives about 15,000 people the use of the sewers. There are six main sewer outlets to the St. Mary river, four to the Maumee and none to the St. Joseph river. These sewers empty both above and in the city limits and cause a great deal of complaint in the summer time. An orphans' home with 50 inmates and an infirmary with 200 inmates are sewered to the St. Mary river just above the city. Four large packing houses and reduction works are on the banks of the river and send all their waste to them. A gas works, tannery and brewery are sewered direct to the river. Quite a number of large shops have their outhouses

for employes on and over the river banks. The worst thing of all, however, is the night-soil. That is dumped over the Maumee river bank about two miles below the city. Thirty-five thousand people are not connected to the sewers and have to depend upon vaults. At the usual figure, this would give 7,000 barrels of night-soil that must be dumped into the river annually. The Maumee is so polluted below town that it will not freeze, and with eight inches of ice on the river above the sewers and dumps.

St. Joseph River—This stream drains part of Williams and Defiance counties in Ohio, and part of Michigan and Indiana. On its watershed are the towns of Montpelier and Edgerton in Ohio, and Waterloo, Butler, Garrett and Auburn in Indiana. The watershed in Michigan contains no urban population.

Garrett, Indiana—Population 3,500. This town has both sanitary and storm sewers and a public water supply. The sewers empty into Cedar creek, which gets all the surface drainage. There are about 200 connections to the sanitary sewers, representing about 1,200 people. Of these 200 connections, 50 are for water closets and the rest for vaults and cesspools. The town is a railroad division point and its business depends upon this.

Auburn, Indiana—Population 2,427. This town has no water supply or sewers whatever. Its surface drainage is to Cedar creek, a branch of the St. Joseph river.

Waterloo, Indiana—Population, 1,600. This town has no water supply or sanitary sewers, but has a fair system of storm water drains which empty into Cedar creek and into ditches leading to it. There are six or seven closets connected to one of these storm drains which cause a nuisance in the summer when the water is low in the creek. The only manufacturing in town is the usual saw and grist mills.

Butler, Indiana—Population 2,700. This town has a public water supply, but no sanitary sewers. There are a few storm water drains which empty into a small run which empties into the St. Joseph river. There are a few water closets connected to the drains, but the small amount of sewage seems to cause no nuisance. The manufacturing products are bicycles, windmills, baskets and canned goods.

Edgerton—Population 1,170. The village has no paved streets, water supply, electric lights or sewers. Some of the streets have tile drains emptying into the St. Joseph river, which runs just east of town. There are no closet connections to these drains, every one depending upon vaults. These are mostly built of brick or stone and some are water-

tight; a few have no vault or pit whatever. Night-soil is hauled south of the village to a farm through which the river runs.

The private wells are mostly driven, but only 14 to 25 feet in depth; they get their water in a bed of gravel which starts only two feet below the surface. There are two slaughter houses not far from the river, but the refuse is fed to hogs, quite a number of which are kept in town. The industries of the place consist of a basket and handle factory and a saw mill.

Montpelier—Population 2,000. Montpelier has a public water supply from wells and electric lights, but no paved streets or sewer system. Most of the streets have tile drains emptying into the St. Joseph river and a small run which empties into the river. There are two closets and several cesspools connected to the sewers, but no vaults are allowed. It is claimed that the sewers never cause a nuisance, and that there is always some water flowing in the river. The majority of the vaults are merely shallow holes in the ground, these being cleaned out twice a year. Night-soil is hauled to farms west of the village.

The majority of the private wells are drove and from 40 to 50 feet deep, the water being found in a bed of gravel and quicksand below the clay. A few dug wells get water from gravel only eight to 20 feet down. The slaughter houses are one-half mile west of town near an old channel or bayou of the river. The refuse is discharged to this, causing a nuisance in the summer time.

The industries consist of a brick yard and lumber mills. There is also a small creamery on the bank of the river, to which all its waste is sent.

St. Mary River—This river drains parts of Van Wert, Mercer and Auglaize counties in Ohio and parts of Adams, Allen and Wells in Indiana. The only urban population on its watershed in Ohio is St. Mary and in Indiana, Decatur.

St. Mary's—Population 3,500. The village of St. Mary's lies on both sides of the St. Mary river and three miles east of the Grand reservoir which feeds the Miami and Erie canal, which also passes through the town. The village has paved streets, electric lights and a public water supply, but no sewers. The water supply is from wells situated within the corporation. The drainage is to the canal and river, all the street drains emptying into the latter, however. There are no connections to the storm water drains and none are allowed. Several families have cesspools which are cleaned out in barrels, except when they dump them into the gutters as it is claimed. Several of the larger houses near the river have private sewers to it, the hotel also has one. Vaults are required to be

water-tight, but very few are so constructed. Night-soil is hauled outside the corporation line and dumped anywhere.

Private wells still supply most of the drinking water as the public water supply is not generally introduced as yet. Most of the wells are dug and from 10 to 50 feet deep, the water being found in quicksand near the surface, or in clay farther down. The limestone is 125 feet down and a few drilled wells get their water in this.

A small woolen mill and a paper mill discharge their refuse to the canal. It is claimed that the paper mill sends waste to the river at times. The other industries of the town are a chain works, spoke factory, oil well supplies and flouring mills.

During dry weather the St. Mary river gets very low and the small amount of sewage and waste emptied into it causes considerable nuisance. Hogs are kept, many of the pens being built right on the river bank, and these add to the filth of the stream.

Decatur, Indiana—Population 4,500. Decatur has a public water supply and some sewers. The latter empty directly into the St. Mary river. It is estimated that there are about 250 connections to the sewers representing some 1,500 people.

SUMMARY.

From a total urban population of 331,073 on the Maumee watershed, 101,000 have connections to the sewers. Most of this sewage is from indoor water closets, very few places allowing vaults to be connected to the sewers, and cesspools are not common. Sixty thousand of these 101,000 people having sewer connections are in Toledo, and thus have nothing to do with the pollution of the watershed. This leaves 41,000 people, the sewage of which reaches the Toledo water works. Some of this travels over 200 miles, while that from the Lucas county home has only five miles to go.

In but few places, near the center and lower end of the watershed, is the sewage a nuisance, owing to the large amount of water always flowing in the rivers. Fort Wayne, 123 miles above Toledo, is the nearest place where the sewage is considered a nuisance. In many of the towns located near the edge of the watershed, however, the sewage causes a good deal of trouble during low water. This sewage from these out-of-the-way places probably affects but little the purity of the water in the lower part of the Maumee, as it has so far to travel in small streams and rivers where the chances for purification are the best. It is the sewage of Fort Wayne, Defiance and Napoleon that causes the most pollution of the public water supplies. Findlay and Lima may also influence this some, but the chemist and bacteriologist will have to explain their effect, as all visible pollu-

tion is destroyed long before the Auglaize joins the Maumee. In fact the sewage of Fort Wayne and Defiance is soon lost sight of in the large volume of the Maumee, but the short distance and the nature of the stream must prevent complete purification before the river is required to furnish a public water supply.

The population using the sewers is divided among the different rivers as follows:

Auglaize	19,900
St. Mary	1,700
St. Joseph	1,400
Tiffin	1,000
Maumee direct	67,000
Sixty thousand of the 67,000 is in Toledo.	
Total number of people in Maumee watershed	101,000

PUBLIC WATER SUPPLIES OF THE MAUMEE WATERSHED.

There are 15 cities and towns on the Maumee watershed in Ohio that have public water supplies. Of these, ten use deep well water, four use river water and one uses well and surface water. This would seem to make the pollution of this watershed less important than one in which the surface water is more generally used for public water supplies, but unfortunately three of the towns that use the river water are on the lower part of the Maumee river, where they get full benefit of all the accumulated pollution of the watershed. Were it not that the water purifies itself to a greater or less degree during its flow, these towns would have a water supply so polluted that it would be absolutely unusable. These three towns, Defiance, Napoleon and Toledo, also represent 140,000 people or 56 per cent. of the total urban population on this watershed in Ohio. These, together with Findlay and Lima, which use surface water not contaminated with the accumulated filth of their neighbors, represent 191,000 people or 76 per cent. of the urban population on the Ohio part of the watershed. Thus, while the surface water supplies are few in number they represent a large number of people.

The 10 small towns near the edges of the watershed that could get good surface water with some care are so located as to be able to and prefer to get a deep well water which is not susceptible to surface contamination. The towns using this well water are Bluffton, Bryan, Continental or Marice City, Delphos, Hicksville, Montpelier, St. Mary's, Van Wert, Wapakoneta and Wauseon.

Lima has a surface supply from Lost creek, augmented by well water.

Surface Water Supplies.

Defiance—Population 9,759. The Defiance water works is owned and operated by a private company. The franchise was granted the company in 1887 and the plant put in operation in 1888. The franchise is for 30 years, with a clause permitting the city to purchase after 10 years and at the end of any five years thereafter.

It says the following regarding the kind of water to be furnished:

"The water shall be taken from such a point as shall be free from all sewage contamination, and shall be taken from a crib or well, and shall at all times be a good, wholesome water, fit for all purposes of domestic and manufacturing uses."

The water is at present taken from the Maumee just at the southern corporation line and above all local contamination from sewage. The nearest serious pollution of the river being Fort Wayne. The water is not used for domestic purposes at all, its muddiness for at least six months in the year being the principal objection to most of the people, though some complain of Fort Wayne.

The water is pumped from the river to a standpipe by two horizontal, compound, condensing, duplex Blake pumps of 2,000,000 gallons capacity each, which were put in with the works and are in fair condition now. The standpipe is 140 feet high and 20 feet in diameter, giving a capacity of 329,000 gallons. The ordinary pressure is 55 pounds.

There are 18 miles of mains, which give about 65 per cent. of the population access to the water. There are 540 services, of which only about 450 are in use and 27 of these metered. The average daily consumption is about 900,000 gallons and the average for each consumer is about 300 gallons.

The annual water rates are as follows:

Five room dwelling	$5 00
Each additional room	1 00
Private bath tubs, hot	5 00
" water closets	3 00
" stables, one horse and carriage	2 50

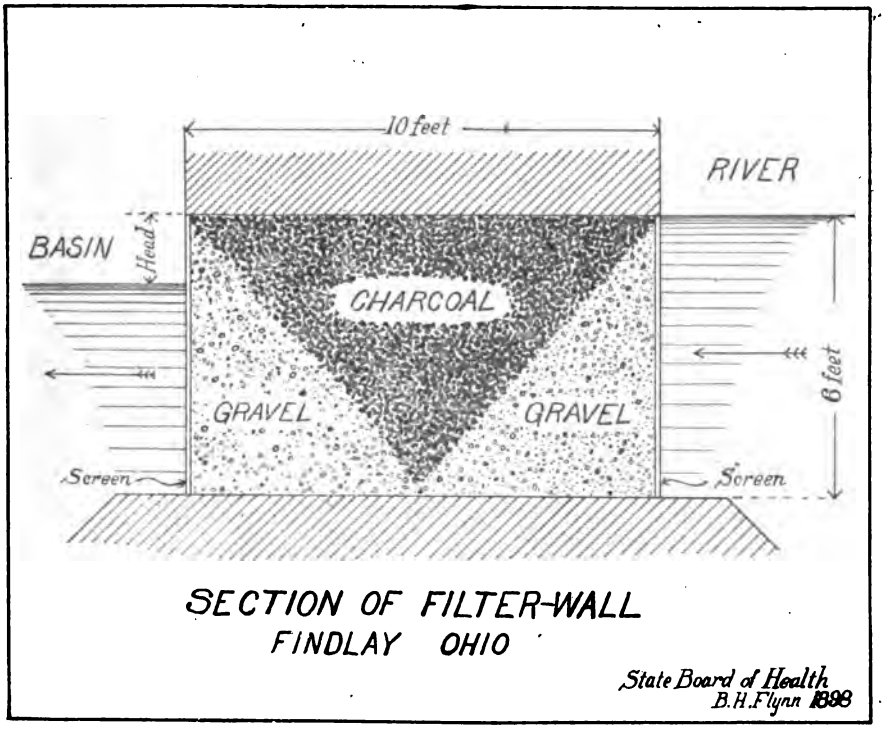
Meter rates per 1,000 gallons:

Below 1,000 gallons per day	40
Two thousand to 3,000 gallons per day	30
Above 10,000 gallons per day	15

Findlay—Population 20,000. The water works was put in by the city in 1889 and has cost to date about $333,000. The water is admitted to a basin from the Blanchard river through a filter-wall separating

the reservoir from the river. The water stands in the basin at the river level minus the friction in passing the filter. Just below the basin entrance a dam has been built across the Blanchard river to keep the level of the water up during dry weather. This dam is 200 feet long and eight feet three inches high, backing the water up some three miles.

The filter is built in the openings between the arches of a masonry bridge or dam across the end of the reservoir. This wall is 295 feet long and the supports for the arches take up 116.5 feet leaving 178.5 feet for the length of the filter proper and as the filter is six feet deep the filtering area is 1,071 square feet. For a section of the filter see cut. The filtering



media is 10 feet thick, the two outside layers being composed of gravel and the inside of charcoal. The gravel is kept in place by screens across the openings under the arches. In filling the filter the gravel was banked against the screens as much as possible and the intervening wedge filled with charcoal; thus the lower part of the filter contains but little charcoal, and as this makes the friction the least near the bottom, most of the water must pass through only gravel giving but little purification.

The filter was designed to free the river water from some of its mud and it does this to a considerable extent. The filter is cleaned three times.

a summer by pumping water through it. The rate of filtration is controlled by gates that can be raised or lowered over the openings between arches. Originally sand was used instead of charcoal and the change was made in 1897.

The water in the basin never appears to be muddy but during low water a scum gathers on its surface and the water smells some. The reservoir is cleaned every other year by draining the water out and by flushing and scraping out the mud. The water is pumped direct from the reservoir to the mains by two horizontal, compound, duplex Gordon pumps of 2,500,000 gallons capacity each. The average daily consumption is 900,000 gallons, allowing 5 per cent. for slip, and the average for each consumer is 140. The average pressure is 70 pounds.

There are about 27 miles of mains, giving 60 per cent. of the population access to the water. There are 1,493 services, of which only 1,036 are in use and 114 of these metered. During the summer when the reservoir is low the public water is not drunk very much and private wells supply most of the water for domestic purposes.

The annual water rates are as follows :

Private houses, per family	$5 00
Each additional family	3 00
Private bath tubs, each	3 00
" water closets, each	3 00
" stables, one horse and carriage	3 00

Meter rates per 1,000 gallons:

Less than 500 gallons per day	12
One thousand to 1,500 gallons per day	10
Over 3,000 gallons per day	6

Napoleon—Population 2,543. The public water supply was put in by the village in 1895. A light plant was put in at the same time and the combined cost was $59,859, to which has been added $5,825 for the water and $3,581 for the light plant.

The supply is from the Maumee river just opposite the south end of town and in the back water of the Grand Rapids dam. The water is in danger of contamination from the sewer emptying just below the intake, and of course it gets full benefit of the sewage of Defiance, 18 miles above.

The water is pumped to a standpipe by two vertical, compound, condensing Smith-Vaile pumps of 1,000,000 gallons capacity each. The standpipe is 125 feet high and 20 feet in diameter, with a capacity of 290,000 gallons.

The average daily consumption is 192,700 gallons, allowing 5 per cent. slip, and the average daily consumption for each consumer is 96 gallons.

The mains give 70 per cent. of the population access to the water. There are 336 connections and 38 of these metered.

The public water is not drunk to any great extent, well water being largely used.

The annual water rates are as follows:

Private houses, five persons or less	$4 00
Each additional person	25
Private water closets, each	2 50
" bath tubs, each	3 00
" stables, one horse and carriage	2 00

Meter rates per 1,000 gallons:

Under 1,000 gallons per day	15
Two thousand to 3,000 gallons per day	10

Toledo—Population 126,000. The water works was put in by the city in 1872, the water being taken direct from the Maumee river as at present. The plant was appraised at $1,416,628.90 in 1894, and $300,000 have been spent on it since, making the present value of the plant $1,716,628, but it is estimated that the plant has cost to date $2,500,000.

The water is led to the pump well by a 5-foot steel conduit and pumped from there to the standpipe by four Worthington and one Knowles pump. Two of the Worthington pumps were put in in 1873, and have a capacity of 5,000,000 gallons each; these are horizontal, compound, duplex pumps. The Knowles is a horizontal, compound, duplex pump of 5,000,000 gallons capacity, and was erected in 1886. One large Worthington was put in in 1893 and its mate in 1898. These are vertical compound, duplex, high duty pumps of 15,000,000 gallons capacity each. This gives a combined capacity of 45,000,000 gallons per 24 hours.

The standpipe is 225 feet high and five feet in diameter, with a capacity of 42,000 gallons. It is used to regulate the pressure only.

There are 152 miles of mains, giving 75 per cent. of the population access to the water. There are 10,200 services in use, of which 4,000 are metered.

The average daily consumption is 7,677,000 gallons, and the average for each consumer is 125 gallons.

The annual water rates are as follows:

Private houses, one faucet	$5 00
Each additional faucet	1 50
Private bath tubs, each	3 00
" water closets, each	3 00
" stable, one horse and carriage	3 00

Meter rates per 1,000 gallons:

Less than 2,000 gallons per day	10
Thirty-five thousand to 55,000 gallons per day	06
Over 170,000 gallons per day	35

The water works intake is located above all Toledo sewer outlets, but it is claimed that the wind raises the water level in the river two feet, and this would be very apt to carry some of the sewage up over the intake. The only serious contamination below Napoleon is the children's home, five miles above the intake, as mentioned in the first part of the report.

Many houses have small filters through which all water for domestic use is passed, and there are quite a number who still use well water. The private wells are nearly all shallow dug ones, from 10 to 20 feet deep, there being but few drove wells in use.

Sewage—The sewage of Toledo bears no relation to water supplies unless it contaminates its own water, but a brief description will be given here:

There are 150 miles of sewer in, with 12 main outlets to the west side of the Maumee, three to the east side, seven to Swan creek and three outlets to the Ottawa river, which empty direct to the bay. There are any number of small outlets and some of these are to the Miami and Erie canal. It is estimated that 75 per cent. of the population have access to the sewers and that there are 8,400 connections to same.

Besides the sewage, the rivers and creeks get a large amount of manufacturing waste and refuse, which is dumped directly into them. During the warm weather the mud flats in the river give off pretty foul odors from the decaying refuse deposited on them.

Regulations have just been put in force regarding the construction of vaults, and the city is full of old pits and plank vaults that are loading the soil and ground water with filth.

Surface and Ground Water Supply.

Lima—Population 31,000. The public water supply was first put in in 1885–7 by the city at a cost of $338,000. Many extensions and additions have since been made and the cost to date is much more than the

above figure. The original supply was from an impounding reservoir on Lost creek, which enters the Ottawa river just east of Lima. A dam 10 feet high and 30 feet long has been built across the creek forming a reservoir of six acres in area, and with a capacity of some 10,000,000 gallons. This reservoir is shallow, overgrown with weeds and dirty, and is dry all summer, except for a few stagnant pools. During the winter and spring rains the reservoir fills up and the water is run to a receiving well from which it flows by gravity to the storage reservoirs. There are two storage reservoirs side by side which have a combined capacity of 120,000,000 gallons. These reservoirs had to be filled formerly during freshets or hard rains and then to supply the city until another rain came, and if the water was low the first part of the rain had to be caught. This first water was merely the washings from the watershed and was pretty foul, especially as there are a large number of oil wells within the drainage area and all their waste oil is washed into the reservoir by the first downpour.

The storage reservoirs have an area of 21 acres which gives them a depth of 17 feet. The sides and bottoms are the natural clay with no paving or riprap. These reservoirs have been cleaned only once, but there has been no trouble except for one year when a green growth appeared.

There was soon a great deal of complaint about the water and in 1894 eight wells were put down at the head of the impounding reservoir. These wells are from 150 to 200 feet deep and eight inches in diameter. A four-inch suction leads to a 1,000,000-gallon pump operated by a motor supplied with electricity from the central pumping station. The water is lowered from near the surface to 22 feet below it by a short period of pumping, as the wells are too close together. This water is pumped to the receiving well and flows to the storage reservoirs by gravity.

In 1897 one more well was put down on Lost creek near the P., F. W., and C. railroad, and an old oil well was also utilized. These wells are 10 inches in diameter and have a six-inch suction leading to a 1,000,000-gallon pump operated by an electric motor. This water is also sent to the receiving well and then to the reservoirs. It is estimated that the wells supply 1,250,000 gallons per day. The water is pumped from the storage reservoirs direct to the mains by two horizontal, compound, duplex Holly pumps of 3,000,000 gallons capacity each.

The average daily consumption is 1,900,000 gallons and the average for each consumer is 120 gallons.

There are 35 miles of mains giving some 80 per cent. of the population access to the water. There are 2,589 connections in use, of which 50 are metered.

Annual water rates are as follows:

Private houses, five rooms or less	$5 00
Each additional room to eight	1 00
Private bath tubs, each	3 50
" water closets, each	2 50

The meter rate is $15 per year as the minimum charge for which 75,000 gallons of water may be used and a charge of eight cents per 1,000 is made for all above that amount.

Ground Water Supplies.

Bluffton—Population 1,400. The water supply was put in by the city in 1896 at a cost of $17,000, which is nearly all the cost to date.

The supply is from eight wells eight inches in diameter and from 35 to 50 feet in depth. Only six of these wells are connected to the pumps. The limestone lies within a few feet of the surface and the wells get their water in this rock. The water rises to within five feet of the surface and can be lowered by the pumps to the suction limit, about 28 feet. The water is pumped to an elevated tank by a horizontal, simple, duplex Stillwell-Bierce-Smith-Vaile pump of 750,000 gallons capacity.

The tank is 20 feet in diameter and 30 feet high, with a capacity of 70,000 gallons, and it is placed on a steel frame tower 82 feet in height, this gives an average pressure of 35 pounds on the street level.

The wells have always supplied plenty of water but for use in cases of emergency an eight-inch intake pipe has been run to an old stone quarry, near the water works. This quarry contains about three and one-half acres and the water is from three to 20 feet deep; the upper five feet, or about 4,000,000 gallons, can be drawn off by the pumps. This emergency intake has not been used within the knowledge of the present engineer or for a year at least.

There are three miles of mains in giving about 90 per cent. of the population access to the water. There are 157 services in, of which 155 are in use and only one metered.

The average daily consumption is about 50,000 gallons, the estimate of the engineer only. The average daily consumption per consumer is only 55 gallons. This is low, especially as two railroads use the water.

The annual water rates are as follows:

Private houses	$5 00
" bath tubs, each	2 00
" water closets, each	5 00
" stables, one horse and carriage	1 50

Meter rates per 1,000 gallons:

Five hundred to 1,000 gallons per day	10
Three thousand to 4,000 gallons per day	6

Bryan—Population 3,176. The public water supply was put in by the village in 1893–4, and has cost to date $45,000.

The supply is from 13 wells, eight of which were put down in 1893, and for fear that these might not supply enough water five more were put down later. These wells are from 95 to 112 feet in depth, 4½ inches in diameter, and go through hard-pan, cement-gravel, quicksand and into gravel where the water is found. When not being pumped all the wells flow and plenty of water has always been supplied, the water level never going below the suction of the pumps. The wells flow to a common main to which the suction of the pump is attached. The water is pumped direct by two horizontal, compound, duplex Hughes pumps of 1,000,000 gallons capacity each.

There are 14 miles of mains in, which give 90 per cent. of the population access to the water. There are 348 services in, of which only about one-half are in use all the year round, the others used in summer only. None of the services are metered. The average daily consumption is 400,000 gallons and the average for each consumer is about 160 gallons. This is due to the large amount of water used for sprinkling in the summer.

The annual water rates are as follows:

Private houses, five persons or less	$4 00
Each additional person	25
Private bath tubs, each	2 00
" water closets, each	3 00
" stables, one horse and carriage	2 00

Continental—Population 1,500. The water works was put in by the village in 1894, and has cost to date about $7,000.

The supply is from a well 75 feet deep and eight inches in diameter. The well strikes the limestone 48 feet down and the water rises to within 13 feet of the surface. It is pumped to a standpipe by a deep well pump of 100,000 gallons capacity. The pump cylinder is 20 feet below the surface and the water can be lowered 45 feet if necessary, but it has never reached this limit, as the well has always supplied enough water. The standpipe is 10 feet in diameter and 100 feet high, with a capacity of 40,000 gallons. The deep well pump keeps the standpipe full for ordinary service. During a fire a 100,000-gallon simple, duplex Still-well-Bierce pump draws from the standpipe and pumps direct into the mains.

There are 2¼ miles of mains, giving about 50 per cent. of the population access to the water. There are 75 services, of which 55 are in use and two of these metered. The average daily consumption is 45,000 gallons or an average of 125 gallons per consumer.

The annual water rates are as follows:

Private house	$6 00
" bath tubs, each	3 00
" water closets, each	3 00
" stable, one horse and carriage	4 00

The meter rate is 15 cents per 1,000 gallons.

Delphos—Population 4,100. The water works was put in by the village in 1896, and has cost to January 1, 1898, $79,452.81, which is practically the cost to date. The supply is from seven wells, eight inches in diameter and from 191 to 300 feet in depth. Six of the wells flow to a receiving well, and one of them is pumped to it by a Stillwell-Bierce air-lift. This one well furnishes nearly all the water; it flows naturally at the rate of 56,000 gallons per day, and is pumped at the rate of 185,000 gallons per day. The wells obtain their water from the Onondago limestone, which is 20 feet below the surface. The water rises to within eight feet of the surface, and during a test one well was lowered 20 feet by pumping at the rate of 85,000 gallons a day. The receiving well is 40 feet in diameter and 37½ feet deep, with a capacity of 235,000 gallons. It is excavated into the rock and the sides walled up with brick. Surface water is admitted by several tiles just above the rock, so as to relieve the pressure on the outside of the walls. The well is covered with a conical board roof.

Before the air-lift was put in the water was almost unusable from the large amount of sulphur present, but the aeration afforded by the air-lift seems to have overcome the objection, and the water is free from the taste and smell of sulphur. A strong odor of sulphur is noticed in the receiving well, and the water as it comes from the air-lift has a milky appearance.

The water is pumped from this well to a standpipe by two horizontal, compound, duplex, Laidlow-Dunn-Gordon pumps of 1,000,000 gallons capacity each. The standpipe is 20 feet in diameter and 130 feet high, with a capacity of 305,000 gallons, and gives an average pressure of 55 pounds.

There are 15.38 miles of mains, giving 90 per cent. of the population access to the water. There are 324 services, of which 244 are in use and four metered. The average daily consumption is 185,000 gallons per day, and the average per consumer is 60 gallons.

The annual water rates are as follows:

Private houses, five rooms or less	$3 00
Each additional room	25
Private bath tubs, each	2 00
" water closets, each	2 00
" stables, one horse and carriage	2 00

Meter rates per 1,000 gallons:

Less than 1,000 gallons per day	25
More than 5,000 " " "	10

Hicksville—Population 3,569. The water works was put in by the village in 1890, and has cost to date about $22,000. The supply is from seven wells, four of which are 32 feet in depth and six inches in diameter, two are 132 feet deep and six inches in diameter and one is 132 feet deep and three inches in diameter. The deep wells go through about 120 feet of clay, sand and hard-pan, and find their water in sand and gravel above the Ohio black shale. All the wells flow with a head of about four feet when not being pumped, but do not supply enough water in the dry spells.

The wells are pumped by direct suction, only six of them being attached; one flows to a small reservoir 100 feet square and holding 387,000 gallons, which is kept on hand for an emergency. This reservoir is used for fire purposes only, but causes a good deal of complaint, as the consumers fear that it is being used at other times. The water is pumped direct to the mains by two horizontal, simple, duplex, non-condensing Hughes pumps of 750,000 gallons capacity each.

There are 4½ miles of mains, which give some 80 per cent. of the population access to the water. There are 237 services and 217 in use, with none metered. The average daily consumption is 150,000 gallons and the average for each consumer is 115 gallons.

The annual water rates are as follows:

Private houses, five persons or less	$4 00
Five to 10 persons	5 00
Private bath tubs, each	2 00
" water closets, each	2 50
" stable, one horse and carriage	2 00

Montpelier—Population 2,000. The water works was put in by the village in December, 1895, and has cost to date about $26,000. The supply is from three drilled wells, 113 feet deep and eight inches in diameter; only two of the wells are in use now. The wells go through clay, fine sand and into gravel where the water is found. The water rises to within 28 feet of the surface, and as the wells are pumped by direct suction

the pumps have been placed in a well 20 feet deep, and they can lower the water the suction limit or about 45 feet from the surface. The suction from the pumps is six inches in diameter, and goes down 36 feet into the casing.

The water is pumped to a standpipe by two horizontal, compound, duplex, non-condensing Worthington pumps of 750,000 gallons capacity. The standpipe is 12 feet in diameter and 110 feet high with a capacity of 93,000 gallons, and gives an average pressure of 38 pounds. There are four and one-half miles of mains giving some 90 per cent. of the population access to the mains. There are 209 services in and 206 in use, of which only one is metered. The average daily consumption is 130,000 gallons and the average for each consumer is 105 gallons.

The annual water rates are as follows:

Private family	$2 00
" water closets, each	2 50
" bath tubs, each	1 50
" stable	1 00
Lawn sprinkling	3 00

The meter rate for the one consumer is five cents per 1,000 gallons.

St. Mary's—Population 3,500. The water works was put in by the village in 1895 and has cost to date about $57,500. The supply is from four drilled wells from 262 to 272 feet in depth and eight inches in diameter. The wells strike the limestone at 125 feet and get a very hard water from this rock, which also contains some sulphur and iron.

The wells flow to a covered receiving well 38 feet in diameter and 28 feet deep, giving a capacity of 237,000 gallons. During the test one well was lowered 13 feet and could be sent no farther with the means at hand.

The water is pumped from the receiving well direct to the mains by two horizontal, compound, duplex, condensing Smith-Vaile pumps of 750,000 gallons capacity each.

The ordinary pressure carried is 50 pounds. There are 12½ miles of mains which give 75 per cent. of the population access to the water. There are 280 services, of which 275 are in use with seven of these metered.

The average daily consumption is about 100,000 gallons and the average per consumer is 60 gallons.

The annual water rates are as follows:

Private houses, per family	$4 00
" water closets, each	2 00
" bath tubs, each	2 00
" stable, one horse and carriage	1 00

The meter rate per 1,000 gallons is 10 cents, with a minimum charge of $10 per year.

Van Wert—Population 7,000. The water works was put in by the town in 1891 and has cost to date $130,000. The supply is from nine wells six inches in diameter and 200 feet deep. The water in found in limestone which commences 40 feet below the surface. The water rises to within from 12 to 18 feet of the surface and is pumped down about 40 feet. The pumps are set in a well 20 feet deep. The water is pumped direct from the wells to the mains by two horizontal, compound, duplex, condensing pumps of 1,500,000 gallons capacity each. The pumps are of the Gordon pattern but were put in by the Holly Company. A reservoir, 165 feet square, 18 feet deep and holding 3,000,000 gallons is used to store the water for an emergency. The reservoir is near the pumping station and is kept full of well water all the time and is only drawn on by the pumps in case of fire, when the wells could not supply the sudden increase in the demand.

There are 19 miles of mains, which give about 70 per cent. of the population access to the water. There are 830 services, of which 550 are in use and seven of these metered. The average daily consumption is 225,000 gallons and the average per consumer is 70 gallons.

The annual water rates are as follows:

Private house, five persons or less	$5 00
Each additional person	25
Private bath tubs, each	3 00
" water closets, each	3 00
" stables, one horse and carriage	2 50

Meter rates per 1,000 gallons:

Five hundred gallons per day or less	25
One thousand to 3,000 gallons per day	15
Over 25,000 gallons per day	7

Wapakoneta—Population 4,000. The water works was put in by the village in November, 1895, and has cost to date $58,000. The supply is from nine drilled wells, eight of which are 35 feet deep and six inches in diameter and one is 142 feet deep and six inches in diameter. The eight shallow wells are in two sets of four each, with each set connected to a common main running between the sets. Only one of these shallow wells is in use. This well, together with the deep well, flows to a receiving well. Most of the water that formerly was collected by the shallow wells now enters the receiving well directly through tiles placed in the floor of same. The receiving well is built of brick,

covered with a conical roof, and is 30 feet deep, 20 feet in diameter and has a capacity of 70,000 gallons. Both the shallow well and the receiving well get their water from a bed of gravel at the river level. The deep well just enters the limestone, which lies 135 feet below the surface. The water is pumped from the receiving well direct to the mains in summer and to a standpipe in the winter. The standpipe is 125 feet high and 25 feet in diameter, with a capacity of 459,000 gallons. The pumps are horizontal, compound, duplex, made by the John A. McGowan Company, and have a capacity of 1,000,000 gallons each.

There are 11¾ miles of mains, giving some 80 per cent. of the population access to the water. There are 280 services, of which 276 are in use and only one metered. The average daily consumption is 126,000 gallons, and the average per consumer is 75 gallons.

The annual water rates are as follows:

Private house, each family	$5 00
" bath tubs, each	2 00
" water closets, each	2 00
" stables, one horse and carriage	1 00

Meter rate per 1,000 gallons is 10 cents, with $10 for the minimum charge for a small meter per year.

Wauseon—Population 2,210. The water works was put in by the village in 1897, first operated April, 1898, and has cost to date $25,000. The supply is from two wells, each 185 feet deep and eight inches in diameter; only one of the wells is in use now. The wells go through shale, fine gravel and into coarse gravel, where the water is found. The water comes to within 30 feet of the surface, and is pumped to a receiving well by a Downey deep well pump of 400,000 gallons capacity. The water can be lowered 75 feet by this pump, but it has never reached this limit yet. During ordinary pumping, the well not in use and 150 feet away, is six feet. The receiving well is built of brick and is covered with a conical tin roof; it is 19 feet deep and 30 feet in diameter, with a capacity of 100,000 gallons. The water is pumped from this reservoir to a standpipe by a horizontal, compound, duplex, Smith-Vaile pump of 750,000 gallons capacity. The standpipe is 12 feet in diameter and 120 feet high, and has a capacity of 100,000 gallons.

The water works is situated one mile south of the town.

There are 7½ miles of mains, giving 90 per cent. of the population access to the water. There are 125 services in use, of which 20 are metered. The average daily consumption is 45,000 gallons or an average of 60 gallons per consumer.

The yearly water rates are as follows:

Private houses, five persons or less	$4 00
Each additional person	25
Private bath tubs, each	2 00
" water closets, each	3 00
" stables, one horse and carriage	2 00

Meter rates per 1.000 gallons:

Less than 100 gallons per day	30
Five hundred to 1,000 gallons per day	20

SUMMARY.

Of the 221,757 people in the 15 towns having public water supplies, 118,000 of these use the "hydrant" water or at least have it on their premises where it can be used. The water mains are, however, so extensive that some 170,800 of the people could get the water if they so desired. Where the deep well waters are furnished nearly all those that have the water use it for domestic purposes, while the surface water supplied to the five towns is so poor and unpalatable, especially in summer, that the people are compelled to use private well water for domestic purposes. The general public cares little how polluted a water may be as long as it is clear and cool with no unpleasant taste or odor, and so when the surface waters get warm and foul smelling in the summer, or muddy during heavy rains, they turn to the cool and clear well water, which may contain double the amount of pollution that the surface water has and not show it at all.

The following table contains the summary in detail of both the water supplies and the sewage of these same towns:

MAUMEE WATERSHED.

	Water supply.												
	Estimated population 1899.	Source of supply.	Method of supply water.	Ownership of water works.	Date of installation of water works.	Cost of plant.	Miles of mains.	Per cent. of population having access to mains.	Number of services in use.	Number of meters.	Average daily consumption in gallons.	Average daily consumption for each consumer.	Total pumping capacity.
Defiance	9,759	Maumee river	Pumping to standpipe	Private	1888	$400,000	18	65	450	27	900,000	300	4,000,000
Findlay	20,000	Blanchard river	Pumping direct	City	1889	333,000	27	60	1,036	114	900,000	140	5,000,000
Napoleon	2,548	Maumee river	Pumping to standpipe	Village	1895	35,000	.....	70	336	88	192,700	96	2,000,000
Toledo	126,000	"	"	City	1872	2,500,000	152	75	10,200	,000	7,677,000	125	45,000,000
Lima	31,000	Creek and 10 wells	Pumping direct	"	1885	338,000	35	80	2 589	50	1 900 000	120	6,000,000
Bluffton	1,400	8 wells	Pumping to tank	Vill	1896	17.000	3	90	155	1	50,000	55	750,000
Bryan	3,176	13 "	Pumping direct	"	1893	45 000	14	90	260	.....	400,000	150	2,000,000
Continental	1,500	1 "	Pumping to standpipe	"	1891	7,000	3¼	50	55	2	45,000	125	100 000
Delphos	4,100	7 "	"	"	1896	80,000	15⅝	90	244	4	85,000	60	2,000,000
Hicksville	3,569	7 "	Pumping direct	"	1891	22,000	4⅛	80	217	.....	150,000	115	1,500,000
Montpelier	2,000	3 "	Pumping to standpipe	"	1895	26.000	4½	90	206	1	130 000	105	1,500,000
St. Marys	3.500	4 "	Pumping direct	"	1895	57 000	12½	75	275	7	100,000	60	1,500,000
Van Wert	7,000	9 "	"	"	1891	130,000	19	70	550	7	225,000	70	3,000,000
Wapakoneta	4 000	9 "	Pumping to standpipe	"	1895	58,000	11¾	80	276	1	126 000	75	2,000,000
Wauseon	2,210	2 "	"	"	1897	25,000	7½	90	125	20	45.000	60	750,000
Totals	221,757	4 rivers. 1 creek and wells. 10 wells.	6 direct. 1 tank. 8 standpipes.	1 private. ublic	.....	$4,078,000	326.3	.....	16,974	4,272	12,925,700	.....	77,100,000
Averages	14,784	.....	.....	.....	1891	271,538	23.3	77	1,132	285	861,710	104	5,140,000

MAUMEE WATERSHED—Concluded.

	Sewage.							
	Outlet of sewers and storm drains.	Number of outlets.	Is sewage a nuisance?	Does sewage pollute the water supply of same city or village?	Miles of sewers.	Per cent. of population having access to sewers.	Number of closet and vault connections.	Population using sewers.
Defiance	Maumee river and Auglaize river	12, 6,	No.	No.	11 9	60	5	1,500
Findlay	Blanchard river and Eagle creek	5, 4,	Yes.	No.	12.2	50	500	3,000
Napoleon	Maumee river and canal	2, 1,	No.	Yes.	2.8	20	50	300
Toledo	Maumee river, Ottawa river and Swan creek	15, 3, 7,	Yes.	Yes.	150	75	8,400	60,000
Lima	Hog creek, ditches to above	18, 10,	Yes.	No.	25	75	2,500	15,000
Bluffton	Big Reiley creek		Yes.	No.			*10	75
Bryan	Ditches to Beaver creek		No.	No.		Small.	†15	100
Continental	Powell creek and Blanchard river		No.	No.		Very small.	†7	50
Delphos	Jenning's creek and Flat Rock creek	5, 3,	Yes.	No.		"	10	75
Hicksville	Mill creek		No.	No.			†1	6
Montpelier	St. Joseph river		No.	No.		Very small.	†9	60
St. Mary's	St. Marys river		Yes.	No.			*10	70
Van Wert	Town creek	18	Yes.	No.	4.2	20	60	400
Wapakoneta	Auglaize river		Yes.	No.		10	40	250
Wauseon	Ditches to Turkey Foot creek	7	Yes.	No.	5.2	60	65	450
Totals			9 Yes. / 9 No.	2 Yes. / 18 No.			11,927	81,236
Averages						26	795	5,422

* Private sewers. † Connected to storm drains.

First Report

UPON THE

CONDITION OF THE

Public Water Supplies of Ohio.

BY THE OHIO STATE BOARD OF HEALTH.

1899.

Reprinted from the Thirteenth Annual Report of the Ohio State Board of Health.

REPORT UPON THE CONDITION OF PUBLIC WATER SUPPLIES OF OHIO.

Under the provisions of the act of 1898, the State Board of Health is required to report annually upon the condition of public water supplies.

The scope such an inquiry may take is only limited by the amount of money which can be devoted to it. As the act referred to carried no special appropriation, the Board deemed it advisable for this year to offer a preliminary report upon the present condition of public water works, and, to some extent, their sources of supply. The inquiry has been further limited by considering only supplies taken in whole or in part from surface waters. This selection was made, as the surface supplies are most liable to pollution, and are also of more importance as regards the number of persons using such water. Besides, the special preliminary report upon sources of water supplies, published last year as a special report, contains an excellent account of the deep well supplies prepared by Prof. Orton, State Geologist.

The wisdom of providing for a study of and annual report upon the condition of our public water supplies will not be questioned. Nothing more nearly touches the public health than the purity of the water supply; and the condition of the public supplies can only be known by a systematic, continued study of the various sources from which they are derived. We feel confident that the value of this work will be seen, and that means will be provided for a more thorough and comprehensive study of the subject hereafter.

It is noted elsewhere in our annual report for this year that the Board is engaged in a study of all important streams in the State, and this report upon the condition of water works with surface water supplies should be read in connection with the reports upon stream conditions.

The report here given concerns 58 cities and villages using surface water in whole or in part, and with a combined estimated population of 1,459,919.

Each of these cities was visited by the engineer, who obtained his information at first hand, when possible, and when not, from the local engineer, superintendent of water works, health officer or other person best informed upon the subject. It is astonishing to find the little atten-

tion given in many places to keeping records of public works, and it has often been impossible to obtain desired information.

Special attention was given to sources of pollution within 10 miles of the intake of any water works. This distance was taken because of the provisions of Section 2433, which is as follows:

"The jurisdiction of any corporation owning water works, to prevent or punish any pollution of the water, shall extend 10 miles beyond the corporation limits." (66 v., 209.)

It should by no means be inferred that this Board gives support to the idea set forth in this statute that water sufficiently purifies itself in flowing a distance of 10 miles. It was simply desired to point out obvious sources of pollution within that distance, which under present laws water works companies have power to prevent.

Following is the report of Mr. Flynn, the engineer engaged for this work:

SURFACE WATER SUPPLIES.

BY B. H. FLYNN, C. E.,

ENGINEER OHIO STATE BOARD OF HEALTH.

Introduction.

1. Surface Water:
   - A. Ohio River.
   - B. Interior Streams.
   - C. Lake Erie.
   - D. Wells and Galleries Supplied by Surface Water.
2. Subsurface Water:
   Galleries and Wells Supplied by Subsurface Water.
3. Surface and Ground Water.
4. Subsurface and Deep-Seated Water.

INTRODUCTION.

There are 71 cities and villages in the State that have water works supplied either wholly or in part with water from surface and subsurface sources. Of the 39 which are supplies directly by surface water six receive surface water through galleries or wells, 10 are supplied by subsurface water and 16 have combined supplied of surface and ground water.

Owing to lack of information as to the source of the public water supplies, and the inability of the engineer to visit every town in the State, it will, probably, be found that there are a few subsurface supplies not included in the above number.

The term subsurface is applied to those waters which lie just beneath the ground level. The water may lie in sand and gravel from an old river bed, in loose rock, or in the ordinary soil, and is in reality a ground water, but it has but recently left the surface on which it fell as rain and contains nearly as much of the impurities due to surface pollution as the water which ran-off in the streams instead of soaking into the ground. On some occasions this subsurface water might contain more of the surface pollution than the run-off water. Light rains would leach out the impurities, soak into the ground, and give no run-off; heavier rains would first soak into the ground until that first became saturated and more impervious, then the water would run-off in the surface streams carrying any objectionable water left.

Sewers discharging into flowing streams would not affect this subsurface water to any appreciable extent, but those sewers discharging into small ditches, which are dry in summer and give the sewage a chance to soak into the ground, would seriously pollute this subsurface water.

Leaky vaults, surface privies, night-soil burying grounds and garbage dumps are probably the chief source of pollution of this water.

In course of time this subsurface water percolates through crevices and porous material and becomes the deep-seated water. It has undergone a process of filtration and purification and may contain but little of the organic pollution in the original water. There is no sharp line between subsurface and deep-seated water, but it is intended to keep in the former class all those waters the purity of which is plainly influenced by surface pollution.

The supplies have been divided into the following classes: Surface water, subsurface water, and combined supplies, that is, supplied in part by surface water and the rest by ground water.

The surface water supplies have been divided into four subdivisions depending upon whether the source was (1) the Ohio river, (2) interior streams, (3) Lake Erie, or (4) wells and galleries supplied by surface water.

The combined supplies are divided into two classes (1) surface and ground water, and (2) subsurface and deep-seated waters.

The following table shows the subdivisions, number of towns in each and the aggregate population of the towns in each class:

Source.	Number of towns.	Total population.
1. Surface water—		
(a) Ohio river	11	487,738
(b) Interior streams	21	346,734
(c) Lake Erie	6	411,127
(d) Wells and galleries supplied by surface water	7	18,760
Total	45	1,264,359
2. Subsurface water—		
Wells and galleries supplied by subsurface water	10	95,929
3. Combined supplies—		
(a) Surface and ground water	14	341,875
(b) Subsurface and deep-seated water	2	7,892
Total	16	349 767
Grand total	71	1,710,055

There are 82 cities and villages with a total population of 404,993 which are supplied with ground water. These are mostly small towns with populations varying from 250 to 2.000 or 3,000. There is one city with a population of about 90,000, two with populations between 20,000 and 30,000, three between 10,000 and 20,000 and 12 between 5,000 and 10,000 and 64 with populations below 5,000.

It is thus seen that the surface water supplies are of greater importance than the ground supplies, more than four times as many people being dependent upon the former as upon the latter. This ratio would be increased if all subsurface supplies were considered. It does not matter much how these supplies are classified as long as it is borne in mind that nearly 2,000,000 people are dependent for water upon supplies that are liable to be polluted by the neglect and carelessness of their neighbors or themselves.

There are 153 towns with a total population of 2,115,048 that have a public water supply of some kind. Thirteen of these towns, with a total population of 6,353, are not classed as urban as their individual populations are below 1,000.

One hundred and ten towns, with a total population of about 200,000, have no public water supplies. This number includes only one town, Jackson, of more than 5,000 people, seven with populations between 3,000 and 5,000, 19 with populations between 2,000 and 3,000, and 85 with populations below 2,000 and above 1,000.

The total urban population of Ohio, as estimated for 1899, is 2,308,695. This includes all towns of 1,000 or more inhabitants.

Thus over 91 per cent. of the total urban population has a public water supply of some kind or other. That is, the above percentage live in towns that have water supplies, though all of each town's population cannot obtain the public water as the mains do not cover all the territory within the corporate limits, and all the people accessible to the mains do not use the water from them. It is a very difficult matter to bring about the abandonment of a well which has been in use for many years seemingly with no ill effects.

Following are the towns examined, grouped with reference to the source of supply:

1. Surface water.

(*a*) Onio river. Cincinnati, Bellaire, Bridgeport, East Liverpool, Ironton, Martin's Ferry, Marietta, Portsmouth, Steubenville, Toronto and Wellsville.

(*b*) Interior streams. Alliance, Bucyrus, Cambridge, Defiance, Dennison, Elyria, Findlay, Fostoria, Lisbon, Monroeville, Napoleon, Norwalk, Oberlin, Piqua, Toledo, Uhrichsville, Upper Sandusky, Warren, Wellston, Youngstown and Zanesville.

(*c*) Lake Erie. Ashtabula, Cleveland, Conneaut, Lorain, Port Clinton and Sandusky.

(*d*) Wells and galleries supplied by surface water. Fairport, Gallipolis, Greenfield, Painesville, Richmond, Ripley and Willoughby.

2. Subsurface water.

Wells and galleries supplies by subsurface water. Ashland, Attica, Circleville, Greenville, Hillsboro, Kenton, Lancaster, Nelsonville, Springfield and Wadsworth.

3. Combined supplies.

(*a*) Surface and ground water. Akron, Bellevue, Canton, Columbus, Crestline, Fremont, Harrison, Lima, Marion, Massillon, Niles, Ravenna, Tiffin and Wooster.

(*b*) Subsurface and deep-seated water. Eaton and Wapakoneta.

The cities taking water direct from the Ohio river have unquestionably a poor supply. The river is subject to such frequent changes in level that the water is muddy for the greater part of the time, and it is always polluted with sewage. It is impossible for the large cities on the Ohio river to discharge all their sewage into it without dangerously polluting the same. The large volume of the stream is the only thing that prevents it from becoming an actual nuisance.

The solution of the water question for these river towns is a difficult matter. The protection of the stream from pollution is a problem to be solved only by national authority, as the stream and its branches pass through and by so many states. The small towns may obtain a usable water by means of wells and galleries in the bed of the stream, but this method has not as yet been made practical for large cities. Gallipolis and Ripley obtain river water in this manner.

Three large cities are trying to solve the question by filtration, which seems to be the only thing left.

If raw sewage is allowed to go directly into the river, it must sooner or later be abandoned as a source of water supply, or the water must first be carefully purified.

The problem of a pure water supply for the cities using the interior streams should be of much easier solution, but unfortunately it is not.

The State Board of Health controls the introduction of new sewer systems, but cannot as yet condemn those already in. Thus there are a large number of towns using water from rivers which receive the sewage of all the towns above them, some of which are but a few miles distant. The report on the Sandusky watershed shows an example of this which would be hard to equal. That which permits this gross violation of sanitary law is the popular fallacy of the self-purification of streams in a few miles of flow. It is unfortunate that all visible pollution does disappear after a short flow, and this is the only criterion to the popular mind. As the work of chemically and bacteriologically examining river water continues the danger of using a sewage polluted water will become better recognized, and the measures for prevention of pollution more easily enforced.

As a class the supplies from the interior streams are bad, nearly all of them suffering more or less from sewage pollution.

Alliance, Fostoria, Norwalk, Oberlin and Wellston impound the waters of small streams, which are comparatively free from sewage pollution. Cambridge, Dennison, Findlay, Uhrichsville and Monroeville use the water direct from streams having little sewage pollution. Piqua obtains its water supply from a branch of the Miami and Erie canal at a point where the sewage pollution is not evident. The remaining 10 cities use a water which is seriously polluted with raw sewage.

With cities taking water from Lake Erie the question of a pure supply lies with each town itself. The lake as a whole is free from serious pollution on account of the enormous dilution suffered by the sewage emptied into it If this sewage is kept away from the intakes a pure supply of water can be had. Port Clinton, Ashtabula and Conneaut receive a water which, as yet, is not badly polluted, but if the sewer systems are extended and the sewage discharged directly into the lake at the present outlet the water will not long remain pure, and new intakes farther removed from the sewage will have to be built.

Painesville collects the lake water by means of galleries, and has a good supply. Sandusky gets a water from the Sandusky bay, which is subject to local sewage pollution. Lorain has a supply from the lake, opposite Black river, which carries a great deal of sewage; the city, however, filters the water before using it. Cleveland obtains the lake water from a crib 1¼ miles out, but even at this distance the water is not free from sewage. In order to obtain a pure supply the city has under construction an intake tunnel which will obtain the lake water four miles from shore, and in connection with this contemplates building a large intercepting sewer to carry all the sewage 10 miles down the lake.

The five supplies from wells and galleries supplied by surface water are good. Painesville, Fairport and Richmond have a common supply from galleries on the shore of Lake Erie. Ripley has wells on the banks of the Ohio river and obtains the river water, together with some ground water. Gallipolis has a system of wells, or rather filter boxes, in the bed of the Ohio. Greenfield and Willoughby have wells supplied by small streams.

The subsurface supplies are on the whole good. Circleville and Springfield obtain an excellent water from extensive gravel beds by means of galleries. Lancaster obtains a supply from the same source by means of a gallery, but the water is unquestionably seriously polluted by sewage being emptied onto the ground almost directly over the gallery. Ashland, Attica, Greenville, Hillsboro and Nelsonville obtain a similar water by means of wells. Wadsworth obtains a supply from springs and wells, which are influenced by the surface water. Kenton obtains its water from a hole excavated in the limestone rock. The supply is prob-

ably largely surface water which has percolated through crevices in the rock. The level varies with local conditions; therefore showing no remote origin of the water.

The surface and ground supplies are so varied that no general statement can be made, and the detailed reports following must be consulted. There are two reasons for the use of the two kinds of water which will apply in most cases. First, the original supply was from ground sources, and, the quantity not being sufficient, recourse had to be made to a surface water, usually with detriment to the quality of the water; or second, the original supply was from surface sources, and an attempt to improve the quality has introduced the ground water, but the latter not being sufficient in quantity has compelled the surface supply to be retained in part at least. This latter reason is by far the most common one with the supplies under consideration.

In the present list there are only two towns given using a subsurface and deep-seated water. This class, together with the subsurface supplies, has not been thoroughly worked up, and the results are given for what they are and not as representing a complete canvass of the State.

Following are reports on the different supplies examined, grouped according to the classification above. With the report on each water works there is annexed a short description of the private wells of the town, and also of the sewerage, together with a few remarks on the general sanitary condition:

All the facts pertaining to the pollution of the water supplies of Alliance, Columbus, Kenton, Niles, Warren and Youngstown have been taken from the report by Prof. C. N. Brown, contained in the special report of the Ohio State Board of Health for 1898.

1. SUBSURFACE SUPPLIES

(a) OHIO RIVER

CINCINNATI, Hamilton county, population 375,000. This city is the metropolis of Ohio. The actual population of the community is much larger than the above figure as there are a great many suburb towns supported entirely by Cincinnati. Across the river, in Kentucky, are the cities of Covington, Newport, Dayton and Bellevue, many of the people of which are employed in Cincinnati.

Cincinnati besides its large amount of general manufacturing is a shipping and commercial center of growing importance.

Water supply—Owing to the improvements in the water supply of Cincinnati, which are now under way, only the briefest review of the present plant will be given.

The first public water works was put in in 1820 by a private company operating under a 99-year franchise granted in 1817. The plant changed hands several times and a number of attempts were made to sell it to the city during the next 15 years. Finally, in 1839, for the sum of $300,000 the city obtained possession of the plant, consisting of a pump house, two pumping engines, reservoir, 19 miles of wooden pipe, three and one-half miles of iron pipe, land, etc.

The water works has steadily grown from that time until it now consists of six stations, supplying seven different services. Four of the stations and five of the services are supplied with water from the Ohio river through the main station on Front street. The Linwood station supplies two services from driven wells. The Front street station pumps the river water to the Third street reservoir and to Eden Park reservoir. The Third street reservoir supplies the low land along the river front and the Eden Park reservoir supplies the business portion of the city and the strip up the Mill Creek valley. The Eden Park reservoir water is repumped by the Eden Park station and by the Hunt street station to tanks on Mt. Auburn and to a tank in Eden Park. Part of the water of the Third street reservoir is pumped by the Price Hill station to the Western Hills service which supplies two suburban districts. Part is also pumped by the Cumminsville station to supply a small district in the northwestern part of the city. The Third street reservoir was completed about 1850 and has

a capacity of 5,000,000 gallons. The Eden Park reservoir was completed in 1878 and has a capacity of 10,000,000 gallons.

The following table shows the tanks in use:

Name.	Number.	Diameter in feet.	Height in feet.	Total capacity in gallons.
Linwood	1	20	25	54,051
Mt. Auburn	2	40	70	1,128,034
Eden Park	1	30	20	95,178
Price Hill	4	30	50	1,036,388

The total pumping capacity in the Front street station through which all the city water, except that from the Linwood wells must pass is 99,236,160 gallons, divided among 16 pumps of every conceivable make, age and condition. The Linwood station has a pumping capacity of 1,180,800 gallons, making a total primary pumping capacity of 100,416,960 gallons. The four secondary stations contain 10 pumps of 22,451,440 gallons capacity.

The following table gives the make, date of installation, capacity, service and station of all the pumps in use:

TABLE SHOWING MAKE, DATE OF INSTALLATION, CAPACITY, SERVICE AND STATION OF PUMPS IN USE BY CINCINNATI WATER WORKS.

Manufacturer.	Number in use.	Date of installation.	Capacity for 24 hours	Service.	Station.
A. Harkness & Son	1	1851	6,782,400	Third street	Front street.
O. A. Powell & Sons	1	1854	6,782,400	"	"
The Miami Machine Works	2	1874-5	*7,413,120	Eden Park	"
Robert Wetherill & Co. (steam end) / Wilson-Snyder Manufacturing Co. (water end)	2	1885 / 1892	*7,884,000	Eden Park	"
Henry R. Worthington	2	1888	*11,127,600	"	"
The Gordon Steam Pump Co.	1		2,937,600	"	"
Barr Pumping Eng. Co.	3		*4,328,640	"	"
Knowles Steam Pump Co. (Auxiliaries)	1	1892	1,382,400	"	"
Henry R. Worthington (Auxiliaries)	1		6,336,000	"	"
Gordon Steam Pump Co (Auxiliaries)	2		*4,590,000	"	"
The Laidlow-Dunn-Gordon Co	2	1893	*590,400	Linwood	Linwood.
Henry R. Worthington	1		4,567,680	Mt. Auburn	Hunt street.
The Niles Tool Works	1	1869	4,592,320	"	"
Wilson-Snyder Manufacturing Co	1	1893	2,898,720	"	Eden Park.
Holly Manufacturing Co	2	1894	*4,373,920	"	"
Wilson-Snyder Manufacturing Co	2	1893	*541,440	Western Hills	Price Hill.
" " " "	1	1893	372,960	Cumminsville	Cumminsville.
Knowles Steam Pump Co	1	1893	159,840	"	"
The Cook Well Co	1	1893	28,800	"	"

* Capacity of each pump.

The auxiliaries in the above table were introduced about 1892, owing to the broken down condition of the pumps in Front Street Station. The pumps were of the horizontal type and were placed on a boat and on a movable incline, so that the level of the pump could vary with the height of the river, and the water always be kept within the suction distance of the pump.

The following table shows that amount of water pumped by each primary station and the amount repumped by the secondary stations in 1897:

Station.	Amount in gallons.	Per cent. of whole.
Front Street (low service)	2,847 022 474	17.58
Front Street (middle service)	13,334,141,713	82.35
Linwood	11,228,400	.07
Total for primary stations	16,192,392,587	100.00
Hunt Street (Mt. Auburn)	652,938,330	4.02
Eden Park	2,137,178,606	13.20
Price Hill	152,115,359	.94
Cumminsville	95,550,205	.59
Total for secondary stations	3,037,782,600	18.75

The Linwood station was originally owned by the village of Linwood, but when the latter was incorporated with Cincinnati, the water works became part of the latter system. The supply is from two 6-inch wells and two 8-inch wells, each about 100 feet deep. The wells go through sand and gravel to bed rock, the water being found in the gravel.

There are 371.81 miles of mains in, giving nearly all Cincinnati access to the water and also a little outside territory. There are 45,674 services in, of which 2,369 are metered and 618 are for elevators.

The average daily consumption is 43,933,708 gallons, the average per consumer is 145 gallons, and the average per capita is 118 gallons, suggesting that there is still some well water used.

The annual water rates are as follows:

Private houses, one family, one or two rooms	$3 00
" " " three or four rooms	4 20
" " " five or six rooms	5 20
" " " eleven or twelve rooms	8 50
" " " fifteen or sixteen rooms	10 30

Private houses, each additional family	$3 00
" bath tubs, each	2 70
" water closets, self-closing, each	1 50
" stables, one horse and carriage	1 80

Meter rates per 1,000 gallons:

60,000 gallons or less per month	87
637,500 gallons or over per month	87

Owing to the serious pollution of the present water supply and to the inadequacy of the present pumping station, a commission was appointed to recommend a new supply to the city. As a result of the report of the commission the Ohio river is to continue to be the source of the supply, but the water is to be taken opposite California, above Cincinnati, near the Kentucky side, in the channel of the river. The water is to be first passed to large settling basins, then filtered and pumped through the new pumping station to the present distribution system. The site of the intake has been approved by the State Board of Health, but the method of filtration, not yet selected, must meet with their approval. The pollution of the river above the water works intake consists of the sewage of the eastern part of the city and the sewage of Bellevue, Dayton and part of Newport, also sewage brought down by the Little Miami river. The Cincinnati Health Department has a list of 21 sewers which empty above the water works; two of these are storm sewers only, but the drainage is from the dirty streets and yards and makes it almost as objectionable as the true sewage. It is impossible to estimate the number of people tributary to these sewers, but it is not large compared with the population of Cincinnati, as intercepting sewers carry much of the sewage below the water works.

Sewerage. Cincinnati has the combined system of sewers with outlets to the Ohio river and to Mill creek. The sewers empty at the most convenient point into the streams, but seem to cause no nuisance, owing to the large amount of water usually available. This is not true, however, of Mill creek, which is badly polluted and has for many years been a source of annoyance. The sewers cover the large central portion of the city, leaving only the outskirts unprovided. No estimate can be given of the sewer connections, as no records have been kept.

Vaults must be 10 feet deep, constructed of masonry and cement and eight feet from wells and cisterns. Owing to the poor construction of the vaults and the short distance, the well water cannot help being polluted.

BELLAIRE, Belmont county, population 12,036. The city is supported almost entirely by its mining, iron and clay interests. The river's

bank is lined with large blast furnaces and steel plants, which give employment to large numbers of men. The city has paved streets and electric lights, but it has a somewhat dirty appearance, as might be expected from the nature of its industries.

Water supply—The water works is owned by the city, and has cost to date about $200,000. The first supply was introduced in 1872, the water being taken from the river just above the outlet of Indian run.

In 1884 a new intake just below the creek was put in. These two furnish the water for the city at the present time, though the water before it reaches the intake is polluted by the sewage of the city itself. The sewage from the northern part of the city empties into Indian run some distance back from the Ohio river. The sewage then flows down to the river right over the old intake and then goes on to the new one. To make matters worse, a large steel plant just north of the run has dumped a large amount of ashes and slag into the river until quite a projection is formed. This causes the water in the river to eddy just below it, so that some of the sewage that empties into the river below the water works is carried up stream and over the intakes. Besides their own sewage the Bellaire water works receives the benefit of the sewage of Martin's Ferry, Bridgeport, Wheeling Island and Wheeling, all within five miles of the intakes. These cities represent a population of 53,700. Of these, 36,500 are accessible to the sewers and some 9,000 are already connected.

The water is lifted by two pumps to a reservoir 215 feet above the low water mark of the river. One pump, built in 1878, is of single acting plunger type, with four pump cylinders at the water level, operated by an engine and gearing, giving a daily capacity of 500,000 gallons. The other pump is of the same pattern; only the cylinders are double acting. This pump was put in in 1884, and has a capacity of 2,000,000 gallons per 24 hours. The pumps are old style and in pretty bad shape at present.

The reservoir has a capacity of 1,500,000 gallons when the water stands 14 feet deep. It is carefully constructed of brick laid in cement, and is fully protected from surface water. The reservoir is cleaned every year and no trouble is experienced from growths of any kind.

Nearly every one in the city has access to the water mains. There are 1,785 services in use, of which two, used by railroads, are metered. The average daily consumption is 2,000,000 gallons. It is estimated that the three large enameling works use one-third of this. Leaving out these manufacturing plants, the average daily consumption per capita for the population actually supplied is about 125 gallons. The water rates are as follows:

Private houses, three rooms or less	$5 00
" " each additional room	75
" " each additional person over five	65
" water closets, each	2 00
" bath tubs, each	3 25
" stables, per head	1 50

There are no strictly private wells in the city. The wells are on the streets or public squares and the water is carried far and near. There are seven of these public wells, averaging 75 to 100 feet deep, and driven into the gravel bed to the level of the river. There are no dug wells in town.

Sewerage—The combined system of sewers is in use, with outlets to the McMahan creek, Indian run and Ohio river. About 75 per cent. of the inhabitants has access to the sewers and probably half of these are connected. The sewers emptying into the Indian run and McMahan creek cause a nuisance in dry weather, as these two creeks are practically dry.

As stated above, parts of the sewage system pollute the city water supply.

Vaults are required to be water-tight, but few are so constructed, the great majority being walled up with boards. No distance is specified from wells.

Night soil is carried to the country and buried.

BRIDGEPORT, Belmont county, population 4,579; and MARTIN'S FERRY, Belmont county. Population 9,736. These two towns are practically one, as far as location is concerned; the corporations join. They are typical river towns, supported by the iron industries and the coal mines. They both have paved streets, electric lights, a few sewers and a common water supply.

Water Supply—Martin's Ferry has a public water supply, put in by the city in 1887, which had cost to January 1, 1898, $167,000. Arrangements have been made by which Bridgeport has the use of the Martin's Ferry water at the same rate as the citizens of that town enjoy. Bridgeport owns and controls its own mains, which were put in shortly after the completion of the works by Martin's Ferry. The citizens of the former town are dissatisfied, however, and are contemplating the erection of a plant for themselves, but they will have difficulty in securing a site as favorable as that of the Martin's Ferry station. This pumping station is situated on the banks of the Ohio river above the city and away from all local pollution. The first source of this is the sewage of Mingo Junction and Steubenville, 19 miles above. Of course the Ohio river receives

more or less pollution from surface drainage between these points, but the amount is insiginificant when compared with the large amount of water usually coming down the river.

The water is pumped from the Ohio river to a reservoir 300 feet above low water. This reservoir has a capacity of 2,500,000 gallons, with a depth of 10 feet. It is cleaned every year, nothing but the mud settled out of the water is removed, and there is no trouble from growths of any kind. The sides of the reservoir are ripfapped and the bottom paved and cemented.

There are two pumps in the station, both vertical, compound, duplex pumps, with differential plungers. One is a Gordon-Maxwell of 1,000,000 gallons capacity, erected with the works in 1887. The other is a 2,000,000-gallon Hughes pump, put in in 1893. The average daily consumption is 1,500,000 gallons, of which it is estimated one-third is used by Bridgeport. Practically all of both towns have access to the water mains. In Martin's Ferry there are 1,133 services in, of which 1,037 are in use, six of these being metered. In Bridgeport there are 425 services in use, of which only one is metered. The average daily consumption per capita for the population actually supplied is 160 gallons.

The water rates are as follows, alike for both towns:

Private house, two rooms	$4 44
" " four rooms	6 38
" " six rooms	8 04
" " ten rooms	11 40
" " each additional room	84
" bath tubs, each	3 34
" water closets, each	3 34
" stables, per stall	1 66

Meter rates per 1,000 gallons:

Five hundred gallons or less per day	30
One thousand to 2,000 gallons	20
Three thousand or over	10

There are no wells in use in Martin's Ferry, but it is estimated that 30 per cent. of Bridgeport's population use well water, a few, filtered cistern water, and the rest the public supply. Private wells are from 30 to 40 feet deep, getting the water in the gravel bed at the river level.

Sewerage of Bridgeport—Bridgeport has the combined system of sewers, with outlets to the Ohio river and Wheeling creek. It is estimated that 90 per cent. of the population have access to the sewers and that 25 per cent. of these are connected. This would give about 1,000 people the use of the sewers, with some 4,000 so situated as to be able to

use them if they so desired. The sewage seems to cause no nuisance and does not pollute the public water supply in any way.

Vaults are constructed of planks and are in a very bad condition generally. During the hard rains the vaults are filled and the ground soaked with the filth washed from them. This could be remedied by making the vaults water-tight and by cleaning them frequently. Night-soil is taken to the country and buried.

Sewerage of Martin's Ferry—Martin's Ferry has a rather poor sewer system. The combined system is used, with three main outlets to the Ohio river. Not more than 15 per cent. of the city's population has access to the sewers, and not a fourth of these are connected. This gives some 600 people the use of the sewers and only 2,500 accessible to them. The sewage causes no nuisance and does not pollute the local water supply.

Vaults are mainly constructed of planks and very few are water-tight, but this does not make so much difference here, as it is claimed that there is not a well in use in Martin's Ferry. Night-soil is buried in the country.

East Liverpool, Columbiana county, population 20,000. This town is one of the growing manufacturing centers of the State. It has electric cars and lights, paved streets, a water supply and a fair sewer system. The principal industry is the manufacture of all kinds of brick, tile and pottery.

Water Supply—The water works was put in by the city in 1879, and has cost to date about $210,000. The supply is from the Ohio river and through a 30-inch intake 480 feet long and leading to a small pump well. The water works is situated above all local pollution, the nearest serious sewage pollution being Allegheny and Pittsburgh, some 35 miles above.

The water is pumped to the low service reservoir 320 feet above the river, and, by an auxiliary station, pumped from here to the high service reservoir, 280 feet above the first, or it can be pumped direct to the upper reservoir from the intake station.

The low service reservoir has a capacity of 2,500,000 gallons, with a depth of 19 feet, and the high service one holds 1,500,000 gallons, with a depth of 15 feet. The reservoirs are both built of brick laid in cement, and both are without covers. The lower reservoir has to be cleaned twice a year, a large amount of mud being removed; the upper one not so often on account of the sedimentation the water receives in the first one.

The main pumping station contains two pumps of 5,000,000 gallons total capacity. One is a vertical compound, duplex Cope and Maxwell pump of 1,500,000 gallons capacity, erected in 1880. The other is a ver-

tical compound, duplex Gordon pump of 3,500,000 gallons capacity, put in in 1892. Both of these pumps can be run single or duplex.

The upper reservoir and pumping station were built in 1892. This station contains a horizontal compound, duplex Gordon pump of 2,000,000 gallons capacity. There are some 23 miles of mains, giving 80 per cent. of the population access to the water. There are 1,600 services in use, with 10 of these metered. The average daily consumption is 2,000,000 gallons, and the average per consumer is 200 gallons.

The annual water rates are as follows:

Private houses, five rooms or less	$6 65
" " each additional room	1 00
" " each additional family	6 65
" water closets, each	3 04
" bath tubs, each	3 33
" stables, one horse and carriage	3 33

Meter rates per 1,000 gallons:

Two hundred gallons or less per day	40
Five hundred gallons to 1,000 gallons per day	25
Twenty thousand to 50,000 gallons per day	7

The public water supply is used for domestic purposes by nearly every one that has it. There are about 250 private wells in use; these are mostly dug and from 20 to 60 feet deep, the lower ones getting their water in the river gravel.

Sewerage—The storm water is conducted to the river through gutters principally, there being but few storm water drains in use. There are about eight miles of sanitary sewers in, with two outlets to the Ohio river. Some 60 per cent. of the population have access to the sewers. There are 630 connections to these, representing about 4,000 people.

No new vaults are being allowed where access to the sewers can be had. The old vaults are not water-tight and no distance from wells is specified. Night-soil and garbage are dumped into the river or buried along its banks.

IRONTON, Lawrence county, population 13,229. This city is the county seat of Lawrence county, and one of the principal manufacturing towns in the southern part of the State. It has a number of well-paved streets, street cars, water works, and a sewer system. The whole river front is lined with manufacturing plants, iron, clay and lumber being the principal products handled. Besides these staples there is a large amount of general manufacturing.

Water Supply—The water works was put in by the city in 1871, and has cost to date $192,000. The supply is direct from the Ohio river at a point opposite the lower part of the city. The water is pumped direct from the intake pipe to the mains, so the city has to take the water as it comes. A reservoir will soon be put in which will help the water some. The local pollution of the river must be called serious. On the river bank above the water works there are five large lumber yards and mills, three iron furnaces, two fire brick plants, a nail mill and soap works. The surface drainage from all these plants goes direct to the river. The banks are practically made up with their refuse, including enormous heaps of decaying sawdust. The nail mill seems to send no acid to the river, as it has a drain to a creek which empties below the water works. The soap works has a sewer direct to the river, through which is discharged the refuse of the plant. This is a very offensive pollution. Three storm water sewers enter the river above the water works, bringing in the dirty surface water of a part of the city.

Big Ice creek enters the river 2¾ miles above the water works; it brings in the drainage of the principal cemetery, the polluting influence of which is uncertain. The county infirmary is located about one-fourth of a mile from this creek and one-half a mile from the river. It has some 85 inmates, the sewage from whom is emptied over a bluff and soaks away into the ground. This may in time cause some pollution, but does not as yet.

Of the towns above Ironton the following are within ten miles: Ashland, Catlettsburg, Sheridan and Coal Grove. Of these, the only one of importance is Ashland, Ky.; this is a growing town of some 6,000 people. It has a partial system of sewers and is at present extending them. There are as yet but few connections and the pollution of the river is not serious, but will be in time.

When the sewerage system of Ironton was put in the principal question was whether to carry the sewage below the present intake or to move the water works farther up the stream. On account of the growing pollution of the river above, it was decided to keep the water works in its present place as far removed from the pollution above as possible, and to carry all the sewage of Ironton below the intake.

The intake is 16 inches in diameter and extends 140 feet from low water mark into the river. The water is pumped direct by two vertical, duplex McDonald pumps of 1,250,000 gallons capacity each. One of these pumps was put in place in 1884 and the other in 1892.

There are 209 miles of mains in, giving some 90 per cent. of the population access to the water. There are 1,650 services in, of which some 1,600 are in use. None of these are metered, as the water is too

muddy to permit of their use. The average daily consumption is 1,400,000 gallons and the average per consumer is 145 gallons.

The annual water rates are as follows:

Private houses, one family, one room	$5 00
" " each additional room	50
" bath tubs, each	3 00
" water closets, each	5 00
" stables, one horse and carriage	4 00

Cisterns furnish the principal supply of water for domestic use. These are usually filled with river water, but in a number of cases with rain water. It is said that there are but three wells in town and two of these are not in use; the only one used is a drove well some 130 feet deep.

Sewerage—Ironton has essentially the separate system of sewers. Part of the system carries off storm water and sewage and part acts as an intercepting sewer. Rachel creek flows nearly the whole length of the town, one-fourth of a mile back from and parallel to the river, and empties into the latter below town. This creek carries nearly all the storm water of the town, four small sewers carrying off the remaining portion. Owing to the location of the water works it was necessary to carry all sewage to the lower end of the city, so a sewer was laid under the bed of Rachel creek.

This main sewer is the outlet of all sanitary sewers and also receives the dry flow of a few combined sewers, the storm flow of which passes direct to the ditch. This method keeps all the sewage out of the creek and prevents a nuisance. There are now 3.92 miles of combined and sanitary sewers in, and the system is being rapidly extended. There are 558 connections made to the sewers, and some 40 per cent. of the total population have access to them.

Vaults are now being done away with as rapidly as the sewer system is extended and the connections made. The vaults in use are from 20 to 60 feet deep, going into sand and gravel near the river level. No attempt seems to be made to clean these out, and new ones are dug as required.

MARIETTA, Washington county, population 12,084. This town is the county seat and the oldest place in the State. It has some manufacturing, but the present life of Marietta is the oil boom. It has some fine paved streets, street cars, electric lights and a water supply.

Water Supply—The water works was put in by the town in 1890, and has cost to date $127,525. The supply is direct from the Ohio river through two intake pipes, each 275 feet long and sixteen and eight inches in diameter

respectively. When the plant was first put in it was intended to obtain a ground water from a large well near the river, but the supply was too small and the water objectionable, so direct connection had to be made to the river. The lower part of this well was filled up and the well used to set the horizontal pump in.

The nearest serious sewage pollution of the Ohio river is the cities of Bellaire and Wheeling, some 75 miles above. There are a number of small towns which send some sewage to the river, the nearest of which is seven miles away. This latter place is a small village, with but a few private sewers.

The water is pumped to two tanks by two Gordon pumps, both put in in 1891. One of these is a horizontal duplex pump of 750,000 gallons capacity; this one is placed in a well so as to be within the suction limit for low water. The other pump, put in in the same year, is a vertical compound, duplex pump of 1,000,000 gallons capacity. The tanks are on the hills back of town, which gives them an elevation of 206 feet above the pumping station. There are two steel tanks, each 66 feet in diameter and 30 feet high, giving a combined capacity of 1,500,000 gallons. There are a little over 21 miles of mains in, giving some 95 per cent. of the population access to the water. There are 1,211 services in, of which about 1,100 are in use and about five of these metered. The average daily consumption is 1,250,000 gallons and the average per consumer is 200 gallons. A great deal of water is used in the flush tanks attached to the sewer system.

The annual water rates are as follows:

Private houses, one to three rooms	$3 00
" " four rooms	4 00
" " five rooms	5 00
" " each additional room	50
" bath tubs, each	3 00
" water closets, each	2 00
" stables, one horse and carriage	3 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	35
One thousand five hundred to 3,000 gallons per day	25
Over 20,000 gallons per day	10

The city water is in general use now, but there is a great deal of complaint on account of its muddy condition for a greater part of the year. The private water supply is limited, there not being more than a dozen wells in use. These are 30 to 40 feet deep, obtaining their water in a bed of gravel at the river level.

Sewerage—Marietta has a system of sanitary sewers with three outlets direct to the Ohio river. These sewers are flushed by tanks and some roof water. The storm water is carried off by surface drains and gutters. There are some 10.3 miles of sanitary sewers in, giving a large percentage of the population access to them. There have been 620 permits issued to tap the sewers, nearly all of which are for water closets. No vaults are allowed to flush to the sewers. The flow from the main sewer, a 2-foot tile, cannot reach the channel of the river during low water, and this causes some nuisance. New vaults must be water-tight, but the old ones are not so constructed and are in bad shape.

Night-soil is buried in the country. Garbage is dumped on the low banks of the Muskingum river.

PORTSMOUTH, Scioto county, population 13,446. Portsmouth, the county seat of Scioto county, is one of the oldest towns of the State. Its industries consist of the usual river trade and some manufacturing. It has a number of well-paved streets, with suitable storm sewers and water supply, but no sanitary sewers whatever.

Water Supply—The water works was put in by the citv in 1871, and has cost to date $185,000. This cost includes the bonds only, and not the amounts spent from the annual revenues. The supply is direct from the Ohio river at a point opposite the upper end of the town. This point is above all local pollution and 27 miles below Ironton, the first serious sewage pollution of the river. Sciotoville is, only six miles above but it is a small village with no sewers.

The water is pumped from the river through two intake pipes, each 20 inches in diameter and extending 550 feet into the river from low water mark. At the end of each pipe is a perforated copper strainer. The water is pumped direct to the mains by two pumps, one a vertical compound, duplex Laidlow-Dunn-Gordon pump of 6,000,000 gallons capacity and the other a vertical compound, duplex Worthington pump of 3,000,000 gallons capacity. The first was put in in 1894 and the other in 1892. It is difficult to keep the pumps in repair owing to the large amount of sand pumped bodily from the river.

There are 25½ miles of mains, which give some 95 per cent. of the population access to the water. There are 3,000 services in, of which 2,550 are in use. Meters cannot be used on account of the mud and sand. The average daily consumption is 1,750,000 gallons and the average per consumer is 185 gallons.

The annual water rates are as follows:

Private houses, four rooms or less	$6 00
" " each additional room	1 00
" bath tubs, each	4 00
" water closets, each	4 00
" stables, one horse and carriage	3 00

There are no private wells in use in Portsmouth. Nearly every one uses the city water, many storing it in cisterns first, to allow sedimentation and to tide over the worst stages of the river. Some of the cisterns are filled with rain water.

Sewerage—There are about 10 miles of storm sewers in use, with one outlet to the Ohio river and two to the Scioto river. Bath and sink connections are made to the storm sewers, but no water closets are allowed, though it is said three or four connections have been made. There are no sanitary sewers in use, every one using the outdoor vault or cesspool. These vaults or cesspools are 20 to 50 feet deep, going into the river gravel, which carries off the liquid, allowing them to fill up slowly with solid matters. When they are full, new ones are dug beside the old and the process repeated. A shoe factory has a large yard punctured with these holes full of filth. This system has polluted the ground water to such an extent that wells are out of the question.

STEUBENVILLE, Jefferson county, population 14,534. Steubenville is he county seat of Jefferson county, and one of the oldest cities in the State. It has quite a number of well-paved streets, fine residences, electric lights, water works and some sewers, all indicating a prosperous community. The principal industries are iron, glass and clay manufacturing, together with more or less coal mining.

Water Supply—Steubenville has had a public water supply since 1810, and the city has always owned and controlled it. The plant complete is valued at $256,457, of which $201,137 has just been spent on the new water works, and the remainder is the valuation of the old plant. The Ohio has always been the source, and will probably so continue to be.

In 1895 a new pumping station was built north of the city, the old one being down in the heart of the business district. The new intake is near the West Virginia side of the river, the channel being on that side at this point, and above all local contamination, a great improvement in this respect over the old location. The only local pollution of the Ohio at the present location of the intake is from the village of Toronto (population 5,000), 6½ miles above the water works. Wellsville (population 7,800) and East Liverpool (population 26,000) are only 18 and 21 miles respectively above the intake. It is not to be expected, however, that the river fully recovers from the effects of the sewage dumped into it from the

dozen or so cities within less than 75 miles; dilution is the only thing that makes the water at all potable.

The water is pumped from the river through two 24-inch intake pipes, which are laid in a trench in the bed rock of the river over to the channel on the West Virginia side. It is claimed that the river is 20 feet deep here during the lowest stages. The two pumps in use now were put in by the E. P. Allis Company in 1895. They are vertical compound, duplex pumps of 3,000,000 gallons capacity each. The water is pumped to a new reservoir having a capacity of 5,000,000 gallons and 312 feet above the pumps. This reservoir supplies direct the high pressure mains used for domestic service. The water flows from this high pressure reservoir to two lower reservoirs. These low pressure reservoirs belong to the old works and have a combined capacity of 2,000,000 gallons. They are about 100 feet above the city, while the high pressure reservoir is 250 feet above. Thus 150 foot pounds of work are lost on every pound of water consumed by a large part of the domestic services of the city. The reservoirs are all paved and cemented, but not covered. They are cleaned once a year by scraping and flushing out the mud.

There are something over 17.5 miles of mains in the low pressure system and about 10 in the high pressure or fire system. These mains give practically the whole population access to the water. There are 3,500 services in, with none metered. There are 2,800 families using the city water, the rest of the services being to shops, stores, etc.

The average daily consumption is 2,200,000 gallons, allowing 2 per cent. for slip of the pumps. The average daily consumption per consumer is 145 gallons.

The annual water rates are as follows:

Private houses, two rooms or less	$2 00
" " each additional room	1 00
" water closets, each	4 00
" bath tubs, each	2 00
" stables, one horse and carriage	2 00

Meter rates range from five to 50 cents per 1,000 gallons.

The city water is used almost entirely; there are very few private wells in use. There are a few dug wells 40 to 50 feet deep and a few springs used for domestic purposes.

Sewerage—There are about 2.7 miles of sewers, with two outlets to the Ohio river and one to Wells run. They carry off some storm water, but most of that is taken care of by surface drains. There are 380 water closets connected to the sewers, representing about 2,280 people. The sewage causes no nuisance, and now causes no pollution of the water sup-

ply. There are no vault regulations. Vaults are usually constructed of brick or plank. Garbage is dumped over the river bank. Night-soil and dead animals are buried in the flats near the river.

TORONTO, Jefferson county, population 5,000. This village is supported almost entirely by the tile industries. It has electric lights, some paved streets and a water supply, but no sewer system.

Water Supply—The water works were put in by the village in 1891, and have cost to date $80,000. The supply is from the Ohio river, through a 16-inch intake, 550 feet long, leading to a small pump well filled by gravity. During high water this well is filled almost to the pumps and sometimes over them. The local pollution to the supply is the small amount of sewage from Wellsville, 10 miles above, and East Liverpool, 13 miles above.

The water is pumped to a reservoir by a vertical compound, duplex Gordon pump of 1,500,000 gallons capacity. The plungers of the pump are 38 feet below the steam cylinders. The reservoir is 325 feet above the pumps and has a capacity of 3,000,000 gallons. It is 145 by 185 feet, giving an area of .65 acres. The sides are made of rubble laid in cement and the bottom is grouted. The reservoir is cleaned out every year. The intake is covered with gravel, and the water of the reservoir can be turned back into the pipe to wash the sand and mud out of the same. It is the aim to fill the reservoir only when the river is clear, and as it holds a ten days' supply, this can be done to some extent

There are nine miles of mains, giving about 90 per cent. of the population access to the water. There are 400 services in use, with three metered. The average daily consumption is 300,000 gallons and the average per consumer is 125 gallons. It is estimated that 90 per cent. of the people drink cistern water. There are not more than a dozen private wells in use.

Sewerage—The surface drainage and sewerage is direct to the Ohio river. There is only one sanitary sewer in town; this covers the three principal streets. There are several storm water drains, some emptying into the river above the water works intake. There are about 25 connections to the sanitary sewers and three or four to the storm sewers. There are several private sewers to the river and a few enter above the water works. The per cent. of the total population having access to the sewers is very small, less than 10.

Vaults are not regulated in any way and none are water-tight. Garbage is dumped over the river bank and night-soil is hauled to the country.

WELLSVILLE, Columbiana county, population 7,800. This village has electric lights, paved streets, electric cars, a public water supply, but no sewers. It is supported principally by its large railroad interests.

Water Supply—The water works were put in by the village in 1881, and have cost to date about $70,000. The supply is from the Ohio river, through a 10-inch intake pipe 600 feet long. The pumps are connected direct to the pipe, the end of which is perforated to act as a screen.

The local pollution of the river is from the sewage of East Liverpool, only three miles distant. The sewage of some 4,000 people in this city is sent direct to the river. The water is pumped to the reservoir by a horizontal compound, duplex Worthington pump of 1,500,000 gallons capacity, erected in 1895. There is an old Worthington pump of the same capacity, put in in 1881, but this is not in use. The pumps are down in a well to bring the river water within suction distance. The reservoir is 350 feet above the pumps and gives a pressure of about 100 pounds on the streets. It is round and has an area of .6 of an acre. The sides of the reservoir are bricked, but not cemented, and are badly overgrown with weeds. The reservoir is cleaned out every year and is in bad condition. There are about eight miles of mains in, giving 90 per cent. of the population access to the water. There are 750 services in use and none are metered.

The average daily consumption is said to be 1,250,000 gallons, but must be less, as this would give an average per consumer of 300 gallons, which is much too large for this town.

The annual water rates are as follows:

Private houses, five rooms or less	$5 00
" " each additional room	1 00
" bath tubs, each	3 00
" water closets, each	2 50
" stables, one horse and carriage	3 00

There are but few private wells in use; these are drilled and get their water in the river gravel. Five of six dug wells get surface water only 15 to 20 feet down. Many families use cistern water for domestic purposes.

Sewerage—There are no sanitary or storm sewers in use. The surface drainage is to the Ohio river, through ditches and gutters. There are about 15 private sewers to the river, to which some 50 families have water closets attached.

Vaults must be 15 feet deep and constructed of brick or stone. None of them are water-tight and no distance is specified from the wells. Night-soil is hauled to farms. Garbage is buried on vacant lots.

(*b*) INTERIOR STREAMS.

The reports upon the water supplies of Defiance, Findlay, Toledo and Napoleon will be found with the special report on the Maumee watershed, and those upon Bucyrus and Upper Sandusky will be found with the special report on the Sandusky watershed. These two reports accompany this report.

ALLIANCE, Stark county, population 11,878. This is one of the many manufacturing towns in the Mahoning Valley. The principal industries are the engineering works, foundries, boiler works, etc. Alliance has a good sewer system, a water works, paved streets and electric lights.

Water Supply—The water works were put in by a private company in 1883. On April 1, 1899, the plant was purchased by the city for $198,000.

The supply is taken from the Mahoning river, just north of town, where the river has a watershed of 73 square miles. This area is devoted almost entirely to agriculture and dairying, there being only a few small country coal banks. There are also several creameries and cheese factories, which were reported to be in good condition, causing no nuisance.

The Fairmount Children's Home, having some 200 inmates and officers, is two miles south of Alliance, and is situated on a small run that empties into the river above the city. They have an underground system of sewage disposal which has worked well so far, but in case of stoppage the sewage would enter the river and endanger the Alliance water. The most serious pollution to the water, however, is a run which passes through part of Alliance and through East Alliance carrying surface drainage and some sewage. It is reported that several private sewers empty into this run, also the drainage from two large manufacturing plants and a hotel.

An intake pipe entering the river above a dam carries the water to a canal, through which it flows for about 600 feet, emptying into a subsiding reservoir, then flowing through another canal about 800 feet long to the pump well. The dam is 125 feet long, six feet high and backs the water up five miles. Five feet of the river water is available for water supply at the dam, but sand bars prevent the water in the upper part of the river from coming down, so that on an average two feet of water is available, or about 25,000,000 gallons, unless the bars are cut through when more could be obtained.

The reservoir is 300 by 400 feet and 3½ feet deep, giving a storage capacity of 3,000,000 gallons. The reservoir and canals are excavated in a mixture of clay, sand and gravel, forming a very fair bottom.

Owing to the rapid growth of water grass and moss in the reservoir, it must be cleaned once a month during the summer or about six times a year. After the first spring cleaning only a small amount of mud is removed each time.

The water is pumped from the small pump well to a standpipe by two pumps, the one put in in 1883 is a compound, duplex Worthington pump of 1,000,000 gallons capacity; the other put in in 1892 is a compound, duplex Worthington of 2,000,000 gallons capacity. The standpipe is 95 feet high, 20 feet in diameter and has a capacity of 220,000 gallons.

There are 13 miles of mains in, giving some 50 per cent. of the population access to the water. There are 1,153 services in, of which 1,000 are in use, and of these 30 are metered. The average daily consumption is 1,400,000 gallons, and the average for each consumer is 230 gallons. The railroads use about 237,000 gallons of water daily, which subtracted from above would make the average daily consumption about 190, which is still much too large, and could easily be reduced by the general introduction of meters.

The average water rates are as follows:

Private houses, one family	$6 00
" bath tubs, each	5 00
" water closets, each	5 00
" stables, one horse and carriage	3 50

Meters are charged a small annual rental, depending upon size. The rates for dwellings per 1,000 gallons is 50 cents and for manufacturing establishments 25 cents.

The city water is in general use where available. The private wells are usually dug and from 15 to 20 feet deep, entering the shale where the water is found.

Sewerage—Alliance has the separate system of sewers. There are 8.6 miles of sanitary sewers in, giving some 75 per cent. of the population access to them. The surface drainage is taken care of by 4 5 miles of storm sewers and by ditches and gutters. Parts of the storm water sewers consist of the old combined sewers, and these are said to have a few closet connections to them still. One of the particularly objectionable storm drains, as mentioned above, empties into the river above the water works. There are 274 connections to the sanitary sewers, most of which are for water closets. The sanitary sewers are connected to a main leading to a chemical disposal works situated on the river bank opposite the water works. This plant was completed July 1, 1896, at a cost of $20,755.62. The operating expenses, repairs, etc., for 1898 were $1,611.75.

The sewage is received into the plant mixed with lime, conducted to the settling basins without previous screening of any kind, there the sludge is precipitated and the clarified effluent is permitted to pass to the river.

There are three precipitation tanks, 40 by 80 feet, and when full containing six feet of sewage. These are constructed in a substantial manner, with brick walls covered with stone copings, and each connected by suitable piping to a common sludge well of similar construction. When it is necessary to clean out a tank it is disconnected from the rest, the sewage is allowed to settle, the clear water drawn off by a skimmer pipe and the sludge flushed to the sludge well, from which it is pumped to the filter press and pressed into cakes. These sludge cakes are carted to a dump, which is the only nuisance of the plant, as the stuff is gradually collecting, not being hauled off fast enough.

The chemical mixers, filter press, sludge pumps, effluent pumps, boilers, etc., are all housed in a substantial two-story brick building. On account of the low level of the bottom of the basins, they cannot be drained directly to the river during high water, and so must be drained to a clear water well, from which the water is pumped to the river.

During the year 1898, 176 tons of coal and 64¾ tons of lime were used, 130,000,000 gallons of sewage were treated and 227 tons of sludge precipitated and pressed, or a daily average of 964 pounds of coal, 355 pounds of lime, 1,241 pounds of sludge, 356,000 gallons of sewage, and a daily cost of $4.415.

This gives an average of seven grains of lime to each gallon of sewage, from which resulted about 24 grains of sludge. The effluent is slightly milky, but causes no nuisance in the river.

The construction of vaults is not regulated, so none are water-tight. Night-soil and garbage are hauled to any available farm.

CAMBRIDGE, Guernsey county, population 6,329. Cambridge is a country town, supported by the neighboring farmers and coal miners. It has a few paved streets, a water works, and is now putting in a few sewers.

Water Supply—The water works were put in by the city in 1896, and have cost to date $60,000. The supply is from Wills creek, a sluggish, muddy stream winding in and out among the hills from which every rain washes down the clay and dirt. The only source of pollution within ten miles is the village of Byesville, some six miles up the creek. This place has a population of 1,000. It has no sewers, but all the drainage from yards and streets finds its way direct to the creek. Hog pens are located on the banks of the creek and cattle have access to it at all times. A great deal of water is pumped to the creek from the coal mines.

A small dam in the creek backs the water up over the intake, from which it is pumped to a standpipe by a horizontal compound, duplex Dunn-Gordon pump of 3,000,000 gallons capacity. The standpipe, located on a hill between the station and the city, is 60 feet high and 25 feet in diameter, giving a capacity of 200,000 gallons.

It is estimated that 75 per cent. of the population have access to the water mains. There are 110 services in use, of which 100 are metered. The average daily consumption is 600,000 gallons and the average per consumer is 90 gallons. None of the water is used for domestic purposes, the consumption above mentioned being due to the use of the water by railroads and factories.

All water is supposed to be sold by meter, and meter rates only are quoted in the rules and regulations.

Meter rates per 1,000 gallons:

Less than 100,000 gallons per year	$0 25
Two hundred and fifty thousand to 500,000 gallons per year	15
Over 750,000 gallons per year	8

Private wells furnish fair water, as there are but few vaults in use and these are water-tight. The majority of the wells are dug and from 20 to 30 feet deep, obtaining their water just above the shale, which is found at that depth. There are a few drove wells on the hills, which go through the shale to the sandstone; these furnish a good water, as the shale keeps out most of the surface drainage.

Sewerage—The village is just putting in a sewer on one of the principal streets. It will empty into Wills creek below the water works, and, as it will have but a few connections for some time, will probably cause no nuisance.

There are but few vaults in use, the dry earth closet being the most common substitute. Night-soil is taken to the country and buried.

DENNISON, Tuscarawas county, population 5,278. UHRICHSVILLE, Tuscarawas county, population 5,123. These two villages can very appropriately be considered together, as they have a common water supply. They lie on opposite banks of the Big Stillwater creek, which forms the boundary between them. Both of the places are manufacturing and railroad towns, and dirty and smoky as such towns always are. Each has a number of paved streets, electric lights and the use of water from one of the public works.

Water Supply—Both villages are supplied with water by the Dennison Water Supply Company. There are separate contracts with this company, but they are practically the same for each.

The water clause in the contract with the village of Dennison reads as follows: "The water shall be from filtering galleries or wells adjacent to the Big Stillwater creek, with direct connection to the creek to be used in cases of emergency." The contract is for twenty years, date September 5, 1887. The plant can be purchased by the city any time after fifteen years have elapsed.

The company is at present taking the water direct from the creek, as a new filter is being put in. The water was taken at first by means of a gallery as required in the contract, but the fine mud of the creek soon made the walls of the gallery impervious and direct connection had to be made to the creek. The filter now under construction is fifty-eight by ninety-eight feet, and will contain three feet of gravel and sand screened into three layers from ordinary river gravel. The water will pass direct from the creek to a small well, then on to the filter bed, being collected after passing through the sand by underdrains and emptying into a pump well. There will be nothing to regulate the rate of filtration except the rate of consumption. This filter will be counted a success if it removes the fine yellow clay with which the water is burdened the greater part of the year.

The water is lifted by two pumps two hundred and fifty feet to a reservoir on a hill overlooking the cities. One is a horizontal, compound, duplex Holly pump of 2,000,000 gallons capacity put in in 1892 and the other is a horizontal Worthington pump of 1,000,000 gallons capacity put in in 1888 when the works were first started. The reservoir, capacity 3,000,000 gallons, has brick sides and bottom and no surface drainage can reach it.

Big Stillwater creek above the intake has very little fall. The creek winds in and out among low hills which furnish the clay with which the creek is loaded three-fourths of the time. Most of the land bordering the creek is in pasture. There is only one village, Newport, within ten miles. It is a small place polluting the watershed no more than so many farm houses.

It was very difficult to obtain all the information desired. The number of services in either town could not be learned. The average daily consumption is 1,300,000 gallons. This is due to the large amount used by the railroads It is estimated that about nine-tenths of Dennison has access to the water and about seven-tenths of Uhrichsville. No one drinks the public water on account of the mud and bad color.

The water rates are as follows:

Private houses, six rooms or less	$5 00
" " each additional room	75
" bath tubs, (cold) each	2 50
" bath tubs, (hot) each	3 50
" water closets, each	5 00
" stables, one horse	3 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	35
One thousand to 2,000 gallons per day	25
Over 10,000 gallons per day	15

The private wells in the two cities are mostly dug, the depths ranging from 12 to 50 feet. Owing to the common use of vaults the wells cannot furnish the best of water yet, well water is depended upon almost entirely for domestic purposes.

Sewerage of Uhrichsville—Uhrichsville has the separate system of sewers principally, there being a few storm sewers that have house connections. The sewers empty into Big Stillwater and into Little Stillwater creeks. About 60 per cent. of the population has access to the sewers, but not half of these have connections in. It is estimated that some 1,200 people use the sewers. The one outlet into Little Stillwater creek causes a nuisance when the creek is low. The storm water is taken care of mainly by surface drains supplemented by a few short tiles to which there have been made several house connections.

Vaults are required to be water-tight or of the dry earth pattern. These rules are not strictly enforced however, and they are usually built to suit the owner. No distance is specified from wells.

Sewerage of Dennison—Dennison has combined sewers, all of which empty into the Little Stillwater creek. The sewage of Dennison in connection with that of Uhrichsville makes this creek pretty foul below the outlets especially in the dry summer weather. While about one-half of the village's population has access to the sewers, but very few are connected to them. It is estimated that the sewers are used by about eight hundred people.

Vaults are required to be water-tight but are not so built, every one in town leaking. Quite a number are now being built of thirty-six-inch tile, closed at the bottom with cement forming a tight vault. Night-soil is carried out to the country and buried.

ELYRIA, Lorain county, population 8,252. Elyria, the county seat of Lorain county is one of the prettiest small cities in Ohio. Its connection by electric cars with Oberlin, Cleveland and Lorain makes it an ideal residence place. It has some manufacturing. Its water supply is poor and the question of a new one is being discussed.

Water Supply—The water works were put in by a private company in 1879. On July 1, 1898 the city obtained control of the plant for a consideration of $45,000. The plant originally cost much more than this. The supply is from the west branch of Black river. The water is impounded by two dams, the first one is at the southern edge of town near the water works and the second is a little over one and a half miles farther up the river. The dams are each eight feet high and one hundred and thirty feet long, but the first backs the water up one mile and the second two and a half miles. It is estimated that the combined storage capacity of the two impounding reservoirs is 150,000,000 gallons. This figure is much too high, probably 75,000,000 gallons is nearer the actual capacity. The purity of the water must be affected seriously by some of the following sources of pollution: the surface drainage of the villages of Oberlin, Lagrange, Rochester and Wellington, the effluent from the Oberlin sewage farm, and the sewage from the county infirmary. As Oberlin is a clean, well-sewered town its surface drainage is not as foul as it would be otherwise. The drainage from the small villages mentioned is not much different from that of the whole watershed which is very thickly populated. The influence of the Oberlin sewage farm in not known. The effluent of the farm enters a branch of the Black river seven miles above the water works intake. This effluent at all times is clear and seems to cause no nuisance, but whether the dangerous bacteria are removed from the sewage is by no means certain. The county infirmary is one-half mile southwest of Elyria; the average number of inmates is one hundred and ten. The sewage from this institution enters a small run which empties into the west branch of Black river just above the second dam. In summer this run is dry and none of the sewage reaches the river except what may be washed down by heavy rains. During wet seasons probably all of the sewage is carried to the river. Thus the chances for the pollution of the water supply are quite large. The liability of pollution from the large rural population, the uncertainty of the complete purification of the sewage of Oberlin, and the sewage from the infirmary all combine to make the present source very undesirable.

The water is admitted to a small brick pump well through a 12-inch pipe, which enters the river just above the first dam. The water is pumped from this well direct to the mains by two Worthington pumps. One put in in 1879, is a horizontal, duplex pump of 1,500,000 gallons capacity, and the other put in in 1897, is a horizontal compound, duplex pump of 2,000 000 gallons capacity. The water was formerly pumped to an elevated tank, but the support of this was failing and it was removed.

There are nine miles of mains in, giving some 50 per cent. of the population access to the water. There 636 services in, of which 540 are in use with none metered. The average daily consumption is 800,000 gallons and the average per consumer is 250 gallons.

The annual water rates are as follows:

Private houses, five rooms or less	$5 00
" " each additional room	1 00
" bath, each	3 00
" water closet, each	3 00
" stables, one horse and carriage	1 50

The city water is not used for domestic purposes at all, except in a few cases where private filters are used. There is a private well for every three or four houses; these supply all the water for domestic use. Most of these wells are from 60 to 70 feet deep; the lower 50 feet is in sandstone. There are still a few surface wells eight to 10 feet deep in use. Filtered cistern water is also used to some extent.

Sewerage—Elyria has nine miles of combined sewers and a few short storm water drains. The sewers have two outlets into Black river, nine into its west branch and 15 into the east branch. Most of these sewers empty into the deeper parts of the river and cause no nuisance except in extremely dry weather, while a few empty into shallow places and cause a nuisance in ordinary summer weather. It is estimated that 65 per cent. of the population have access to the sewers, and that there are 350 water closets connected with them.

All new vaults are required to be water-tight, but the city contains many old ones, which are either planked up or have no walls at all. A large number of dry earth closets are in use. Night-soil and garbage are buried on the city dump ground, which is near Black river and some distance north of the city.

FOSTORIA, Seneca county, population 9,000. The population of Fostoria has decreased within the last year, owing to the removal of the glass factories. It is quite a railroad center, five roads going through the place. The industries consist of a large planing mill, a carbon works, incandescent lamp works and the usual small foundries and lumber mills. It has a public water supply and would have an excellent sewer system if it were kept in proper condition.

Water Supply—The water works were put in by the city in 1891 and 1892, and have cost to date $223,580.88.

The supply is taken from Portage creek one-half mile south of the city by means of a diverting canal. At the head of the canal the creek is pro-

vided with three gates six feet high and seven feet wide, which can be raised and lowered so that when the creek water is objectionable it can be excluded from the canal. This canal, 21 feet wide, two feet deep and 3,400 feet long, carries the water of the creek to the upper reservoir, which has an area of 12 acres and a capacity of 25,000,000 gallons, with a depth of some six feet. From this reservoir the water is led to a lower one by a conduit three feet in diameter and 400 feet long. This reservoir has an area of 18 acres and holds 120,000,000 gallons, with a depth of 19 feet

The upper reservoir banks are not paved in any way, and the site was not stripped of vegetation. The large reservoir, however, is well built, the sides carefully paved, and the bottom excavated to a considerable depth.

Portage creek is dry nearly all the time, as it only has a watershed of some 32 square miles. The reservoirs are therefore filled by storm water only; the main supply coming from the spring and fall freshets. The diverting gates are left open except during flood time, but not closed down until the first flood has washed out the creek.

From the main reservoir the water flows onto a small circular filter, in the center of the bed of which is a small fountain, by means of which the water is slightly aerated. The filter has an area of 6,300 square feet, and the bed consists of a foot of sand on top of 18 inches of gravel. The water is collected by wooden underdrains and carried to the pump well, the surplus going to a small basin holding some 500,000 gallons. The pump well holds 200,000 gallons, giving with the basin nearly two days' supply of filtered water, so-called. The filter acts as a strainer only, removing the coarser suspended particles. It is cleaned yearly by scraping off the top and putting in clean sand. The water is pumped to a standpipe by two horizontal, compound, duplex Gordon pumps of 1,500,000 gallons capacity each. The standpipe consists of a tank 25 feet by 100 feet placed on a stone tower 65 feet high. This gives a pressure of 70 pounds at the station and 60 pounds on the city streets.

There are 17.88 miles of mains, giving some 80 per cent. access to the city water. There are 739 taps in, but only 408 in use, of these 98 are metered. The average daily consumption is 454,000 gallons, and the average per consumer is 180 gallons. This figure includes, however, all the water used by the railroads, factories and by some 34 flush tanks on the sewer system.

In 1895 three wells were put down to supplement the surface water. These are 200 feet deep and 5⅝ inches in diameter. They are connected with an air-lift and are supposed to supply 100,000 gallons each, but they are not in use and have not been for some time.

The water rates are as follows:

Private house, one faucet	$5 00
" each additional faucet	1 50
" bath tubs, each	3 00
" water closets, each	3 00
" stables, one horse and carriage	3 00

The meter rates for 1,000 gallons are:

Twenty-five thousand to 50,000 per year	19½
Six hundred thousand to 700,000 per year	15½
Four million to 5,000,000 per year	8
Over 5,000,000 per year	7

As the city water is muddy at times and is not drunk then, the private supply is important. Nearly every house has a private well; they are mostly drilled and are from 20 to 40 feet deep. The limestone lies about 30 feet below the surface, and most of the wells get their water from or just above it.

Sewerage—Fostoria has spent a great deal of money on her sewers, and would have a good system if they were only cared for properly. There are 23½ miles of sewers, giving some 75 per cent. of the population access to them. There are 250 water closets connected with the sewers; no vaults are allowed to be connected, though a few may be. The sewers at present empty directly into the east branch of the Portage river, but as soon as the sewage farm is in working order all of it will be filtered before it reaches the river. The sewage farm was planned to be a very efficient disposal plant, but the plans have been changed until the working of the plant will be entirely experimental and the results uncertain.

There are nine acres of land laid out in beds and underdrained ready for the sewage. This is to be run to two large tanks and then pumped from these to the beds by a centrifugal pump, operated by a gas engine. No separation of the sludge is to be allowed, everything to be pumped to the beds. This method of applying the sewage will probably resutl in clogging the beds, making it necessary for them to be continually scraped, giving poor results and high operating expenses, the very thing the plans were changed to reduce.

Portage creek was formerly very foul from the sewage, but it has been straightened and deepened, and now is not so objectionable. The local gas plant sends its waste to the creek, which causes as much of a nuisance as anything.

Nearly every house in town has a vault. These are required to be water-tight and 50 feet from a well, but the old ones do not fulfill these conditions. Garbage and night-soil are disposed of individually, usually being taken to the country.

LISBON, Columbiana county, population 2,529. This is a quiet, old village, kept alive by the fact that it is the county seat. It has a few paved streets, water works and a few sewers.

Water Supply—Lisbon has had a water works of some kind or other for the last 50 years, and the plant has always been owned by the village. The first supply was from a small impounding reservoir in the hills back of the town, and was used for fires only. In 1887 four wells were put down near Beaver creek, but these soon failed and direct connection had to be made to the creek. West of the village is a dam on Beaver creek, from which a race runs down to a mill near the water works. A 6-inch main leads from the tail race of the mill to the supply well of the water works. This enables the creek water to be obtained above all local pollution. Eleven miles above the water works the sewage of Salem enters Salem creek, and 10 miles above the drainage of Leetonia enters Leetonia creek; and these two creeks unite eight miles above Lisbon to form Beaver creek. The sewage of Salem is enough to condemn the creek as a source of public supply. Seven miles above the water works a creamery sends its waste to the creek. Just below this a pleasure resort has a dam in the creek which forms a pond for boating. The dam is eight feet high and 50 feet long and backs the water about one-fourth of a mile. The well to which the intake pipe flows is cut out of the rock, and is 18 feet in diameter and 30 feet deep. The water is pumped from this well to a reservoir by a duplex Gordon pump of 500,000 gallons capacity and by a compound, duplex Worthington pump of 1,500,000 gallons capacity. The former was put in in 1887 and the latter in 1895.

The reservoir is 50 feet square and 20 feet deep, with a capacity of 375,000 gallons. It is built of stone laid in cement, carefully protected from surface drainage, but not fenced in or covered.

There are five miles of mains in, giving about 75 per cent. of the population access to the water. There are 250 services in use, of which only one is metered, the water being too muddy for the use of meters.

The average daily consumption is about 200,000 gallons and the average per consumer is 130 gallons.

The annual water rates are as follows:

Private house, six rooms or less	$4 00
" each additional room	50
" bath tubs, each	3 33
" water closets, each	$2 80 to 4 00
" stable, one horse and carriage	3 33

Owing to the muddy condition of the hydrant water for the greater part of the year it is of little use for domestic purposes. The private

water supply is from dug wells 15 to 60 feet deep, depending upon whether they are in the valley or in the hills. The water seems to be obtained from a small vein of iron ore.

Sewerage—The surface drainage and sewerage is to Beaver creek and to a small ditch leading to it. There are about five miles of combined sewers in, with seven outlets to the creek direct and two into the ditch. These sewers give about 75 per cent. of the population access to them. There are not many connections as yet made to the sewers, nearly every one using the outdoor vaults. These are usually boarded up and are required to be 50 feet from the wells. The sewage causes some nuisance when the creek is low, but has caused little complaint on account of the remoteness of the objectionable outlets.

MONROEVILLE, Huron county, population 2,000. This village has a water supply and electric lights, but no paved streets or sewers. The industries consist of an organ factory, bent wood works, and two tile works.

Water Supply—The water works were put in by the village in 1898 at a cost of $19,000. At the same time an electric light plant was put in under the same roof. This cost $11,000. The water supply is taken direct from the west branch of the Huron river at a point near the southern part of town. There are two or three small villages on the watershed of the river, but the pollution is not any greater than from an ordinary rural population.

The intake for ordinary use consists of a conduit five by five by thirty-two feet long extending under the stream. For fire purposes a 16-inch main admits the water direct. The intakes lead to a well 12 feet in diameter and 14 feet deep from which the water is pumped to a standpipe by two pumps. One is a small Rumsey power pump of 25,000 gallons capacity and the other a Hughes pump of 1,500,000 gallons capacity. The small one was put in so that the engine which runs the dynamos at night could pump water in the daytime. The standpipe is 12 feet in diameter by 120 feet high with a capacity of 105,000 gallons.

There are six miles of mains in, giving nearly the whole village access to the water. There are 143 services in use none of which are metered. The average daily consumption in summer is 500,000 gallons and in winter 20,000 gallons. The average for the year is probably about 100,000 gallons and the average for each consumer is 110 gallons. The plant is new and not in perfect running order as yet.

The only rate established is that for a private house which is $5.

The hydrant water is not drunk at all, everyone using well water for domestic purposes. The private wells average 16 feet in depth and obtain their water in a bed of gravel and sand lying just under the soil.

Sewerage—There is no system of sewers in as yet though several houses have private ones to the river. Vaults must be 50 feet from wells, but none are water-tight. Quite a number of houses use boxes which are emptied frequently.

NORWALK, Huron county, population 8,867. Norwalk is the county seat of Huron county. It is quite a railroad town, both the W. & L. E. and the L. S. & M. S. having large repair shops here. There are a number of minor industries also. The town has paved streets, an electric car line to Sandusky, a fair sewer system and a water works.

Water Supply—The first water works was put in by the village in 1871. The supply was from Peru and Coal creeks, pumping direct. This plant has cost $150,000 to date. A new supply is just being introduced from impounding reservoirs on Norwalk creek, which with the new standpipe and pump house will cost $125,000.

For the old supply small dams were built in Peru and Coal creeks and the water pumped direct from the reservoirs thus formed. Then Peru creek was abandoned and the whole supply pumped from Coal creek. This supply became unsatisfactory and the new supply from Norwalk creek is just being introduced.

Two large impounding reservoirs were built on the creek just east of the corporation line. These were formed by building two earthen dams with masonry core walls each 35 feet high, the first or lower one is 2,100 feet long and the upper one 2,125 feet long. The first reservoir is 34 feet above the city and has an area of 35 acres and a capacity of 160,000,000 gallons. The upper reservoir is 61 feet above the city and has an area of 45 acres and a capacity of 220,000,000 gallons. The only pollution possible seems to be from the ordinary rural population.

When the plant is finished the water will be pumped from the lower reservoir to a standpipe by a new horizontal compound, duplex Snyder-Hughes pump of 3,000,000 gallons capacity. The standpipe is to be 30 feet in diameter and 100 feet high, with a capacity of 530,000 gallons. The base of the standpipe is 41 feet above the city streets. In the old station at the junction of Peru and Coal creeks, the water was first pumped by a Holly pump, in 1878 two compound, duplex Worthington pumps of 500,000 and 2,000,000 gallons respectively were put in. During the first part of the last year these pumps supplied the town from Coal creek, now it is supplied by gravity from the new upper reservoir with the old pumps held in reserve for fire purposes.

There are 19.9 miles of mains in, giving some 90 per cent. of the population access to the water. There are 1,072 services in, of which 942

are in use, none of which are metered. The average daily consumption is 1,411,000 gallons and the average per consumer is 240 gallons.

The annual water rates are as follows:

Private house, five rooms or less	$5 00
" " each additional room	50
" bath tubs, each	2 00
" water closets	1 50
" stable, one horse and carriage	3 00

Where available the city water is used entirely. Surface wells supply those unaccessible to the city water.

Sewerage—Norwalk has the combined system of sewers. There are 11.6 miles in, giving some 65 per cent. of the population access to them. The outlet of the sewers in the southern part of the town is Norwalk creek, the northern ones empty into ditches which lead to Huron river. The sewers have been put in piecemeal, and connections are not recorded, so information was hard to secure. It is estimated that one-half of those having access to the sewers are connected, this would make about 30 per cent. of the population. During dry weather the sewage causes a nuisance and an intercepting sewer to carry the sewage below town is talked of. One-half of those not connected to the sewers use dry earth closets. Vaults are constructed in any manner though the law requires them to be water-tight. Night-soil is buried, no special place being provided for it.

OBERLIN, Lorain county, population 5,731. Oberlin is a college town and has no other interests whatever. Its affairs are administered by intelligent men and public improvements should be first-class. It has a number of well paved streets, a good sewer system, and a good water works. It is connected by electric railways to Elyria, Lorain and Cleveland.

Water Supply—The water works were put in by the village in 1887, and have cost to date $81,000. The supply is from the east branch of Vermilion river. The water is brought by gravity to the storage reservoirs through an 8 to 10-inch tile pipe line six miles long. The line is not absolutely water-tight and some ground water seeps in. A small dam two feet high and 32 feet long backs the water up over the intake in the river.

The watershed of the river above the intake has an area of 11 square miles. This area includes nothing but the ordinary rural population and proper care and supervision would reduce the pollution to a minimum. It is said that it is the custom to wash sheep in the river during

shearing time. Another source of pollution may come from the barnyards located near the pipe line as the latter is not water-tight.

The water flows to a large reservoir, then to a smaller reservoir, finally to a pump well, and is then pumped to an elevated tank. The large reservoir was built in 1896 to furnish additional storage so that the low stages of the river could be tided over and the water would have a longer time for sedimentation. The reservoir has an area of about four acres and a capacity of 15,250,000 gallons. This gives a period of six months for sedimentation. The walls of the reservoir are carefully paved and all surface drainage is excluded. The small reservior is a brick well of 1,000,000 gallons capacity. It was originally the only storage available. As the water used is surface water there has been no trouble from growths in the reservoirs.

The two pumps used were put in by the Dean Pump Company, in 1887. They are each of 1,000,000 gallons capacity, but one is compound and the other is not. The tank is 18 feet in diameter and 35 feet high with a capacity of 66,000 gallons and is placed on a stone tower 40 feet high so that the average head against which the pumps work is 80 feet.

There are 8.5 miles of mains in, which give some 80 per cent. of the population access to the water. There are 535 services in use of which 212 are metered. The average daily consumption is 83,000 gallons and the average per consumer is 35 gallons.

The annual water rates are as follows:

Private house, six rooms or less, each family	$5 00
" " each additional room	50
" bath tubs, each	3 00
" water closets, each	3 00
" stables, one horse and carriage	3 00

Meter rates per 1,000 gallons:

Less than 500 gallons per day	30
Over 1,000 gallons per day	20
Meter rent per year	1 50

Where it is available the hydrant water is used entirely. The private water supply is from dug wells from 18 to 23 feet deep which get their water on top of the shale which is found at the above depth. The water is liable to pollution from privies and is considered bad.

Sewerage—Oberlin has the separate system of sewers. The storm water is carried principally by gutters to Plum creek, a branch of the west branch of the Black river. There are 8.6 miles of sanitary sewers in, giving some 80 per cent. of the population access to them. Nearly 1.5 of

this consists of an 18-inch trunk sewer which carries all the sewage to the disposal ground. There are 450 connections to the sewers, of which 400 are for water closets. Cellars are connected with separate drains placed beside the sanitary sewers.

The sewers were put in during 1892-93. The separate system was decided upon as the small flow of Plum creek would necessitate the purification of the sewage. In 1894 the sewage disposal farm was prepared. The village acquired 20 acres of land, lying on both sides of Plum creek and about a mile east of the corporation. Three and one-half acres of this land has been laid out in beds and underdrained for intermittent filtration, and one and three-fourths acres have been underdrained slightly for broad irrigation. The land cost $1,500 and $990 have been spent on construction. From this it can be seen that everything was done in the simplest manner possible. The sewage as it comes from the trunk sewer enters a manhole where the flow can be diverted from one settling basin to the other alternately. There are two of these basins each 32 feet by 10 feet by three feet deep. They are mere pits excavated in the ground, the sides boarded up and covered with a flat board roof. The sewage enters these basins, the heavy matter settles, floating particles are caught by a submerged board, the sewage passes out over a measuring wier and enters a ditch leading to the beds. The three and one-half acres are divided into 12 beds by small earthen ridges one foot high. The sewage is carried to the beds by small ditches and spread over the same by damming the ditch and overflowing the sides, allowing the sewage to run out on the beds. These ditches were made by running a deep furrow with a plow and trimming up the sides with a spade. When it is necessary to divert the flow, a shovelful of earth effectually closes the ditch. The beds are underdrained by two and a half and four-inch agricultural tile placed 20 feet apart. The one and a half acres used for broad irrigation are underdrained only in the low places. The sewage is distributed over this area by small ditches as above.

The soil of the upper part of the farm is composed of clay mixed with gravel and the lower part consists of a sandy loam. The fields are kept in grass principally.

The sludge held in the settling basins is pumped once a week to a tank wagon and hauled to the back of the farm where it is spread over the soil and plowed under. Crude carbolic acid is used in the basins after cleaning to destroy the smell.

The farm disposes of 75,000 gallons of sewage daily and 300 gallons of sludge. The effluent enters Plum creek and is carried to the west branch of Black river. No nuisance is caused at any time and the purification is complete as far as appearance goes.

The population of Oberlin not accessible to the sewers use outdoor privies provided with a shallow pit. Vaults are not allowed. Night-soil is carried to the country.

PIQUA, Miami county, population 13,184. This town is the county seat of Miami county. It is one of the older places that flourished during the canal period in the state. Piqua has paved streets, electric lights and cars, a water works and some sewers. The industries consist of three paper mills, a woolen mill and general manufacturing.

Water Supply—The water works were put in by the city in 1876. The water works proper have cost the city $90,000 to date and the hydraulic canal $269,000.

The supply is from the "hydraulic," a branch and feeder of the Miami and Erie canal. The hydraulic leaves the main canal at Lockington and joins it again below Piqua, gathering up much surface drainage on the way and furnishing a supply of water to Piqua, also the power to pump it and to run several manufacturing plants. Just above the water works the canal broadens into three reservoirs, in all some 100 acres in area. The reservoirs and the canal are badly overgrown with weeds and moss, as the sides and bottom are not paved in any manner. The water is pumped from the hydraulic direct to the mains by two power pumps. One of these is a Flanders pump of 2,000,000 gallons capacity and the other a Gordon-Maxwell pump of 1,500,000 gallons capacity.

There are 24½ miles of mains in, giving some 90 per cent. of the population access to the water. There are 1,400 services in use, none of which are metered. The average daily consumption is 1,500,000 gallons and the average per consumer is 175 gallons.

The annual rates are as follows:

Private houses, kitchen use	$2 00
" bath tubs, each	2 00
" water closets, each	2 00
" stables, two horses and carriage	1 00

The city water is not used for domestic purposes to any extent, the main dependence being placed on private wells. About two-thirds of these are shallow dug ones, from 15 to 30 feet deep, getting their water in a bed of gravel. The others are drilled and go 10 to 12 feet into the limestone which is about 25 feet below the surface.

Sewerage—The separate system of sewers is in use now. One-half of the town is drained by the storm sewers and about one-fifth is reached by the sanitary sewers. The outlets of the sewers are to the big Miami river.

There are 180 water closets and a few vaults connected to the sanitary sewers. The sewage together with the refuse of a woolen mill causes

considerable nuisance, especially during low water. The nuisance is aggravated by the dam two and one-half miles below town which backs the water up to the sewers and prevents the sewage and refuse from flowing away. The dam is four feet high and 250 feet wide, forming a pond area of about 70 acres. A state dam three miles above town keeps the river pretty low at Piqua and also makes matters worse.

Vaults must be 50 feet from wells and water-tight, but neither regulation is enforced. Night-soil is hauled to the country.

The three paper mills discharge their refuse to the canal and make it very offensive at times.

WARREN, Trumbull county, population 8,573. This city is the county seat of Trumbull county. It has a large amount of general manufacturing and not so much of the iron industry that characterizes the neighboring towns. It has 3.6 miles of paved streets, a sewer system and a water supply.

Water Supply—The water works were put in by a private company in 1887. The franchise was granted September 10, 1886, to run for 20 years. It contains a clause giving the city the option of purchasing at the end of any five year period. It also states that the water shall be taken from the Mahoning river, above Camp and Randall's dam and shall be conducted through settling basins or reservoirs and filters to free it from all impurities. The supply is taken from the Mahoning river just above the dam mentioned above. The pollution of the river above the intake consists of the effluent of the Alliance sewage disposal works which enters the river 46 miles above, a number of small villages, the nearest of which is Leavittsburg, the Trumbull County Infirmary and a storm drain in Warren.

Leavittsburg, a village of some three hundred people, is six miles from Warren by river. The surface drainage is reported by Prof. Brown as being particularly objectionable and as a menace to the purity of the river water. The Trumbull County Infirmary has some 125 inmates and officers and is situated 1.5 miles back from the river on Youngs' branch, which enters the river 1.5 miles above Warren, making the infirmary three miles distant by water. The women's building has a complete sewer system and a part of the men have access to sewered closets. The sewage enters the branch direct and must seriously affect the Warren water. Arrangements are now being made to purify the sewage from the infirmary. A storm sewer in Warren, draining a small section in the northern part of the city enters the river only a short distance above the intake. The sewer has no closet connections, but carries much objectionable surface drainage and should be carried below the water works for an outlet.

The dam at the water works is 6 5 feet high, 250 feet long and backs the water up about three and one-half miles. The water before passing to the mains is filtered by a Warren mechanical gravity filter plant of 1,500,000 gallons capacity, installed in 1895. The water is pumped from the river by a centrifugal pump to the settling basin, receiving on the way a solution of alum as a coagulant. It passes through the settling basin onto the filters, through them to the clear water reservoir and is then pumped to the standpipe and mains. The settling basin is about 50 feet long, 22 feet wide and 11 feet deep, holding 80,000 gallons, with a division wall through the center so arranged that the water has to travel the length of the basin twice. The clear water basin is 16 by 30 by 11 feet deep and holds nearly 50,000 gallons. The settling and clear water basins are constructed of masonry and are lined with cement. The filters consist of five wooden tanks, each 10.5 feet in diameter and contain 22 inches of sand. They are the standard gravity Warren filters with suitable screens, piping and mechanical agitator for collecting the filtered water and for washing the sand beds when they become clogged.

The coagulant is measured by a small tubular water wheel actuated by the centrifugal pump, so that the amount of solution is kept in direct ratio to the quantity of water pumped. The amount of alum used per gallon is varied by changing the strength of the alum solution, which is checked by a hydrometer. The amount of alum used is varied with the condition of the water, muddy water requiring much more than clear. The plant uses from 260 to 420 pounds of alum for 24 hours. This with an average daily consumption of about 1,000,000 gallons, would give from 1.8 to 2.9 grains of alum per gallon. This amount of alum should remove a large percentage of the bacteria. The settling basin is cleaned about once a week. Each filter is washed from two to four times a day, depending upon the condition of the water.

The water is forced to the standpipe by two compound, duplex, condensing Dean pumps of 1,500,000 gallons capacity each. The standpipe is 140 feet high, 22 feet in diameter and has a capacity of 398,000 gallons. There are 17 miles of mains in, giving about 60 per cent. of the population access to the water. There are 1,000 services in, of which 903 are in use and 140 of these metered.

The average daily consumption is 1,080,000 gallons and the average per consumer is 200 gallons.

The annual water rates are as follows:

Private houses, six rooms or less	$6 00
" " each additional room	50
" bath tubs, each	2 75
" water closets, each	2 50
" stables, one horse and carriage	2 50

Meter rates per 1,000 gallons:

One hundred to 200 gallons per day	25
Five hundred to 1,000 gallons per day	20
Over 5,000 gallons per day	15

The tap water is satisfactory and is used where available. There are a number of private wells in use and filtered cistern water is drunk to some extent. The wells are dug from 16 to 25 feet deep, and obtain their water from a bed of shale just under the clay.

Sewerage—Warren has the combined system of sewers, with five outlets to the Mahoning river, all below the water works. There are about 12.2 miles in, giving some 70 per cent. of the population access to them.

Vaults, hand-flush closets and cesspools, together with quite a number of water closets, are connected to the sewers. The sewage does not pollute the local water supply, but the lower outlets do cause a nuisance in dry weather. There is one outlet to the backwater of a dam one mile below the water works. This dam is 250 feet long, six feet high and backs the water about three-fourths of a mile. Owing to the clay soil, vaults fill up with water and are but little used. The usual practice is to construct a plank box, which is emptied as necessary. Dry earth closets are used to some extent. Night-soil and garbage are hauled to the country and disposed of.

WELLSTON, Jackson county, population 8,000. Wellston is a coal mining and manufacturing town. There are 11 mines within the corporation limits and many more just outside. There are also two blast furnaces, two ice plants, a foundry and a cement factory located here. The corporate limits include a large, hilly area, so that public improvements are difficult and costly. A few streets have been paved and a water works put in, but there are no sewers whatever as yet.

Water Supply—The water works were put in by the village in 1890, and have cost to date $80,000. The supply is from Little Raccoon creek, at a point just north of town. The creek is dammed at the water works and the water flows by gravity to a pump well. This dam is five feet high, 75 feet long and backs the water up two miles, as far as Hamden. This place is a small village of 900 inhabitants, with no water works or sewers. Its surface drainage is direct to Little Raccoon creek, and this will always be a source of danger to the water supply of Wellston. The pump well to

which the creek water flows is 20 feet in diameter and 27 feet deep. It is built of brick and covered with a conical board roof. The water is pumped from this to a standpipe by two horizontal, duplex Gordon pumps of 750,000 gallons capacity each. The standpipe is 24 feet in diameter and 75 feet high, with a capacity of 250,000 gallons. It is situated on a hill, so that the main street has a pressure of eighty pounds.

During the summer season the creek goes nearly dry and fails to supply enough water. To tide over these dry spells a large storage reservoir is under construction. This reservoir is estimated to hold 85,000,000 gallons, and is formed by building an earthen dam across the end of a valley. The wall is 50 feet high at highest point, 448 feet long on top, and backs the water up 1,220 feet, forming a reservoir of something less than 35 acres in area. The water works owns the whole watershed of the valley, some 50 acres, which will be fenced in and ditched, so that no polluted surface water can reach the reservoir. The reservoir site has been completely stripped of surface soil, so that the water will not suffer any change during storage. Part of the site has been stripped down to bed rock. The inner slope of the earthen wall is three to one and is paved with one layer of brick laid dry, then grouted. A 16-inch main leads from the pumping station to the bottom of the reservoir through which the latter will be filled when the creek is high. This same main will be used to supply the pumps when the creek is low.

There are about nine miles of mains in, which give 75 per cent. of the population access to the water. There are 400 services in, of which 375 are in use and six of these metered. The average daily consumption is 250,000 gallons and the average per consumer is 110 gallons.

The annual water rates are as follows:

Private houses, six rooms or less	$6 00
" " each additional room	1 00
" bath tubs, each	3 00
" water closets, each	3 00
" stables, two horses and cow	5 00

Meter rates per 1,000 gallons:

One to 1,000 gallons per month	40
Five thousand to 10,000 gallons per month	20
Twenty thousand to 30,000 gallons per month	10

The tap water is used more than the number of services show, as many families carry the water from neighboring houses. The private water supply is from a few dug wells, 15 to 30 feet deep. These go through clay and slate and obtain the water in a bed of quicksand.

Sewerage—Wellston has no sewers. The surface drainage is to Bundy's and Meadow runs which empty into Raccoon creek. There are but two

or three water closets in use; these are connected to cesspools. Every house has an outdoor vault which usually consists of an oil barrel, but a few are built of brick. They must be 50 feet from a well. Night-soil and garbage are buried in trenches two miles south of the corporation.

YOUNGSTOWN, Mahoning county, population 50,000 Youngstown is the seventh city in the State and the center of the iron industry in the Mahoning valley. The growth of the city has been rapid, and public improvements have had difficulty in keeping pace with it. A new water supply is now under consideration and the worst fault will probably be soon overcome.

Water Supply—The water works were put in by the city in 1872 and have cost to date $650,000. The supply is from the Mahoning river at a point opposite the center of the city. The pollution of the stream at this point is serious. Besides the sewage and surface drainage of Girard, population 3,000, Niles, population 4,644, and Warren, population 8,573; five, 10 and 16 miles respectively above the water works, the river is polluted by the drainage of the upper part of Youngstown and from a large number of iron mills which line both sides of the river as far up as Niles, and above.

The water from the river is admitted to a screen chamber and then to two pump wells through five 16-inch pipes. It is then pumped through the mains to two standpipes located on the hills on the opposite sides of the river. They are each 30 feet in diameter, 100 feet high, and of 530,000 gallons capacity. The standpipes are cleaned once a year. There are three pumps in use, each of 5,000,000 gallons capacity. One is a horizontal, compound, duplex Dean pump, erected in 1884, and the other two are horizontal, compound, duplex Tod engines put in in 1897. There are 58 miles of mains in, giving some 60 per cent. of the population access to the water. There are 3,100 services in, of which 2,850 are in use, and 250 of these metered. The daily average consumption is 2,500,000 gallons, and the average per consumer is 165 gallons.

The annual water rates are as follows:

Private houses, five rooms or less	$5 50
" " each additional room up to nine	1 10
" bath tubs, each	3 30
" water closets, each	3 30
" stables, one horse	3 30

Meter rates per 1,000 gallons:

For the first 250,000 gallons per year	20
Over 1,000,000 gallons per year	8

The city water is unquestionably bad, and is used for domestic purposes to a limited extent only. The private wells are thus called upon to furnish a great deal of water for this use. These wells are of all kinds and depths, but most of them obtain their water from a porous sandstone which underlies the whole city. This stone readily permits the surface water to soak in, and the water found in it is not of the best.

Sewerage—Youngstown has the combined system of sewers with four outlets to the Mahoning river. Most of the dry flow is carried down below town by an intercepting sewer. There are 28 miles of sewers giving only the business and residence portion of the city access. The large districts occupied by the foreign laboring classes have no sewers whatever. There are about 2,000 water closets connected to the sewers, and a few vaults. In summer when the river is low the sewage becomes offensive and causes a nuisance. Vaults are required to be water-tight and this regulation is enforced in an attempt to protect the ground water. The vaults are constructed of brick and stone laid in cement, and most of them are water-tight.

A few dry earth closets are used. Night-soil is disposed of on the neighboring farms. Garbage is cremated.

ZANESVILLE, Muskingum county, population 24,008. This is a very prosperous and enterprising city, having besides the seven railroad lines, a navigable river to the Ohio. The principal manufacturing products are tile, brick, glass, iron, leather, soap, furniture, canned goods, etc. The city is supported also by quite an extensive coal mining district.

Water Supply—Zanesville has had a public water supply from the Muskingum river since 1840, when the old station below the city was built. As the city grew up the river, it began to pollute its own supply, necessitating the removal in 1873 of the pumping station to its present site above the city. The water is pumped from the river to a reservoir and a standpipe and another reservoir is filled from the first by gravity, thus giving three levels in the city. This is necessary on account of the extreme range in the level of the city due to the surrounding hills. The first reservoir built is now abandoned. The second one, built by the side of the first on Harvey Hill, is still in use, supplying the lowest service in in the city. This reservoir has a capacity of 2,000,000 gallons, and is filled by gravity from the new reservoir on Blandy Hill, which supplies the middle service. The new reservoir has a capacity of 2,500,000 gallons. The high service is supplied by a standpipe on the same hill and is supplied with water direct from the pumping station. The standpipe, built in 1894, is 100 feet high and 25 feet in diameter, giving a capacity of 367,000 gallons. It was formerly supplied by a 1,000,000-gallon Knowles

pump in a station near the new reservoir, but this is not used now. An old standpipe near it has also been abandoned. The reservoirs have brick sides and bottoms laid in cement and are carefully protected from surface drainage. Owing to the large amount of sediment carried by the Muskingum river, the reservoirs have to be cleaned out at least twice a yea . The pumping station contains three pumps: an old style single-acting Worthington, installed in 1873, but since remodeled and compounded, now having a capacity of 3,000,000 gallons; a horizontal compound, duplex Holly pump of 5,000,000 gallons capacity, put in in 1872; and a horizontal, compound, duplex Gordon pump of 2,000,000 gallons capacity, installed in 1895. The discharge pipes from these pumps are so arranged that any or all of them can be used on the high or middle service, the low service being supplied entirely from the middle one.

There are 64.6 miles of mains in, giving some 90 per cent. of the people access to them. There are 5,000 services in use, of which only 50 are metered. This high figure comes from a peculiar method of numbering the permits, some families having two or three services in use. Nearly everyone has the water on their premises, and it is estimated that not more than 20 per cent. drink well water. The only source of pollution to the water supply within 10 miles, is the drainage from the small collection of miners' houses which line the river above the water works. The principal objection to the water is the mud, which drives the people to well water during flood seasons. The average daily consumption is 4,187,000 gallons, and the average per consumer is 200 gallons. This high figure is due to the large use of water for manufacturing purposes.

The annual water rates are as follows:

Private houses, including bath tubs, water closets, basins, etc., $3.70 to $37.50, according to the number of persons in the house and its tax valuation.

Private stables, one horse... ..... $1 00

The meter rate is six cents per 1,000 gallons.

The private water supply is mainly from dug wells 10 to 12 feet in depth. In the western part of the city the wells are driven and from 20 to 30 feet in depth.

Sewerage.—The city is not well sewered. The combined system of sewers is used, with outlets direct to the Muskingum river. Not more than 50 per cent. of the population have access to them and not a large number of these have connections. The sewage causes no nuisance on account of the abundance of water at all times, especially as the river in front of the city is influenced by the government dam just below. This

dam is 8:5 feet high, 736 feet wide and backs the water up five or six miles. Vaults are constructed without regulation, and but few are water-tight.

(c) LAKE ERIE

ASHTABULA, Ashtabula county, population 14,686. Ashtabula consists practically of two towns, the business portion, back from the lake, and the harbor portion, with its elevators, ore hauling machinery, etc. Owing to the poor class of people in the harbor settlement, it has none of the modern improvements that are to be found in the main portion of the city. Ashtabula has about three miles of paved streets, a sewer system and a water supply.

Water Supply—The water works were put in by a private company in 1886. This company operates under a franchise granted September 21, 1886, and expiring 20 years from that time. The city has the option of purchasing at the end of 10 years and at the end of five year intervals thereafter. The franchise provides that the water shall be taken from wells and tubes on the shore of Lake Erie.

The present supply is taken direct from the lake through a 24-inch pipe leading to a submerged crib 2,600 feet from the shore line. Formerly the supply was taken from tubes and wells on the lake shore, but these failed to supply water enough and they were abandoned in 1897 for the present supply. The crib is located in 26 feet of water and the inlet is eight feet above the lake bottom. The crib is 3,500 feet west of the outlet of the Ashtabula river, into which is discharged all the sewage of the city. It is claimed that the prevailing current is eastward, which would carry the sewage away from the intake, but this cannot always hold and the water is liable to pollution at times. The water flows by gravity to a pump well 30 feet in diameter and holding 15 feet of water. From there it is pumped to a reservoir for the low service and to a standpipe for the high service. The reservoir is 216 feet above the pumps, and the top of the standpipe is 100 feet higher. The reservoir is lined with brick laid on puddled clay and has a capacity of 2,225,000 gallons. The standpipe is 100 feet high, 20 feet in diameter, and has a capacity of 225,000 gallons. Both the reservoir and standpipe are cleaned out each year. There are two compound, duplex, Worthington pumps in use, both erected in 1886.

There are about 25 miles of mains, giving some 75 per cent. of the population access to the water. There are 1,300 services, of which 1,100 are in use and 400 of these metered. The average daily consumption is

1,500,000 gallons, and the average per consumer is 225 gallons. The railroads use about 385,000 gallons of water per day, which subtracted from above would leave an average daily consumption per consumer of 170 gallons. The maximum consumption is 2,000,000 gallons, occurring in February.

The annual water rents are as follows:

Private houses, 5 rooms or less	$5 00
" " each additional room	1 00
" " " " family	4 00
" bath tubs, each	3 50
" water closets, each	4 00
" stables, one horse and carriage	3 00

Meter rates per 1,000 gallons:

One hundred to 1,000 gallons per day	30
Two thousand to 5,000 "	20
Over 10,000 gallons per day	10

Wherever available the hydrant water is used for domestic purposes. The private wells are usually dug from 10 to 25 feet deep. The water is found in sand, gravel, shale, or rock, according to the location.

Sewerage—Ashtabula has 4.62 miles combined, 9.96 miles of sanitary and 1.13 miles of storm sewers. There is one outlet of the combined sewers, one for the storm sewer and two outlets for the sanitary sewers, all to the Ashtabula river. About 50 per cent. of the city's population have access to the sewers. There are 206 connections to the sewers recorded, but the city engineer says that there are many more. There are 100 water closets connected with the sewers. The sewage causes but little nuisance owing to the large volume of water. It is probable that at times the sewage pollutes the water supply as mentioned above. Surface privies and dry earth closets are the general rule. Night-soil and garbage are removed to a dump outside of the city.

CLEVELAND, Cuyahoga county, population 350,000. Cleveland is the second city of the State. It has a large suburban population in addition to the above, which will in time be added to it. Besides the large amount of general manufacturing, the iron and shipping industries are very important.

Water Supply—In 1896 Cleveland employed an expert commission to report on an extension of the water works tunnel and an intercepting sewer system. This commission recommended that the new intake should be four miles from shore, opposite the present pumping station, and the new pumping station to be on the east side of town, making the new intake tunnel 26,000 feet long. The new tunnel is nine feet in

diameter. The new location of the pumping station was decided upon so as to avoid the construction of such a long force main to the Fairmount reservoir, which would be necessary if the old site were used. The intercepting sewer is to be laid along the lake front so as to gather up all sewage and carry it ten miles below the Cuyahoga river and away from the intake. This scheme will require the pumping of the sewage from the lower levels and one main station and three substations were provided for. The plans also provide for a tunnel from the lake to the head of slack water in the Cuyahoga through which the lake water can be pumped so as to increase the flow of the river to such a volume as shall prevent all nuisance. The new intake tunnel is well under way.

The water works were put in by the city in 1857, and have cost to date $8,396,480.41. The present supply is from an intake crib northwest of the government breakwater, and 6,625 feet from the shore line. The water is brought to the pumping station through two tunnels; one built in 1874 is five feet in diameter, and the other, built in 1891, is seven feet in diameter. The water flows through these tunnels to a large aqueduct which supplies the various pump wells. From these the water is repumped to Fairmount reservoir for the low service and repumped from there to the Kinsman reservoir for the high service. The reservoirs are located at the farther end of the supply mains and are used to regulate the pumping only.

The following table gives the make, date of installation, and capacity of the pumps at the two stations:

Station.	Number.	Make.	Kind.	Date of installation.	Capacity in 24 hours.
Division street..	1	Worthington.....	Horizontal, duplex, comp...	1876	10,000,000
	1	"	" " ...	1881	10,000,000
	1	"	" " ...	1884	10,000,000
	2	Knowles.....	" " ...	1888	*15,000,000
	1	Worthington,.....	" " ...	1893	15,000,000
	1	Allis	Vertical triple expansion ..	1899	20,000,000
	7	Total on Prim	ary service.....	.....	95,000,000
Fairmount.....	2	Cornish.....	Single-walking beam..	1857	*4,000,000
	2	Total on Secon	dary service..	.....	8,000,000

*Capacity of each pump.

The Cornish pumps were moved from the old pumping station to the present station in 1886, when the high service was started. The present reservoirs were both completed in 1886, the low service using another reservoir before the completion of Fairmount. The Fairmount reservoir has an area of about 12 acres, and with 20 feet of water has a capacity of 80,000,000 gallons. The sides are paved with stone block on puddled clay. No surface drainage has access to it. The reservoir is cleaned every five or six years, not a great deal of mud being removed. The Kinsman reservoir is of the same construction and has a capacity of 37,000,000 gallons.

Cleveland supplies, through meters, the villages of East Cleveland, Glenville and Lakewood. They are considered as large private consumers, each owning and controlling its own water mains. It is estimated that these three places have a population of 5,000 that use the water, or according to the water department rating, there are 714 services in use in these villages.

Within the city limits of Cleveland there are 515.5 miles of mains giving practically the whole population access to the water, 438 3 miles of this are in the low service and 77.2 miles are in the high service. There are 58,030 services and 49,832 in use, of which 2,416 are metered and 185 for elevators. This does not include the services for the suburban villages. The average daily consumption for the whole system is 51,839,816 gallons, the average per consumer is 160 gallons, and the average per capita for the whole city is 148 gallons. This last figure may be large as the city claims a larger population than the one estimated above.

The annual water rates are as follows:

Private houses, three rooms or less	$3 00
" " each additional room	50
" bath tubs, each	2 00
" water closets, each	2 00
" stables, one horse	1 00

The meter rate is five and one-third cents per 1,000 gallons with a minimum rate of $10 per year.

Of necessity in a city of this size the hydrant water is used almost entirely for domestic purposes. There are a few private wells in use in the outskirts, these are usually dug and above 40 feet deep, the water being found in gravel.

Sewerage—Cleveland has the combined system of sewers with outlets to Lake Erie, Cuyahoga river and to Walworth and Kingsbury runs. These two runs are gradually turning into large trunk sewers and cannot be much longer classed as streams. There are 254 miles of sewers, giving

about 60 per cent. of the population access to them. The city is divided into 21 sewer districts, three of which have no sewers as yet and several more have but partial systems. The sewage causes some nuisance at times, especially that part emptying into the Cuyahoga river and it is also liable at times, under the present conditions, to pollute the water supply. The Cuyahoga river receives the refuse from a large number of manufacturing establishments and the sewage of at least one-third of the city, and this, together with the very slow current, causes the river to become very foul, the bottom being covered with black mud which constantly gives off bubbles of very offensive gas and the water itself is black and greasy.

The local health department is compelling vaults to be abandoned and connections made to the sewers so that in the center of the city nearly every place is now connected. All new vaults must be built according to standard plans, which require them to be water-tight. Night-soil is dumbed into the lake opposite Wilson avenue and ten miles out. Garbage is disposed of by the Buckeye Refuse Destruction Company.

CONNEAUT, Ashtabula county, population 7,606. This town is divided into two portions, the main business part, back from the lake, and the part at the harbor. The industries are the elevators, ore handling at the docks, a railroad shop and some general manufacturing in the main part of the city. There is one-eighth of a mile of paved streets, a good sewer system and a water works.

Water Supply—The water works were put in by a private company in 1891. The company operates under a franchise granted June 16, 1890, and to run for 20 years. The franchise provides that the city may purchase the plant at the end of 10, 15 and 20 years respectively, from the time of granting the same. It contains the following in relation to source of the water supply: "The supply shall be ample for all the wants of a place of 10 000 inhabitants, and the water shall be taken from Lake Erie or from filtering galleries, wells or reservoirs built on the shore of said lake, in either case, in such manner as shall furnish a complete and ample supply of good pure water as aforesaid; and if taken directly from the lake, the water so taken shall be filtered or clarified in settling basins in such manner as shall make the same pure, clear and wholesome, and no reservoir other than those situated near the shores of said lake, including one from which the water is pumped shall be used in the operation of said works, and the water shall be taken from a point not less than 2,000 feet westerly of the west pier at Conneaut harbor."

The present supply is from eight Cook tubular wells, driven horizontally in the sand bed of Lake Erie. These wells extend from 200 to 350 feet under the lake and are four inches in diameter. The suction of

the pumps is attached directly to the wells from which the water is pumped through the town to a standpipe back of same. There is a 10-inch pipe extending 300 feet into the lake which is used for emergencies. It is understood that the valve on this pipe is half open nearly all the time as the wells do not furnish enough water. The wells are connected up so that the standpipe pressure can be used to flush out the screens. The water is pumped by two horizontal, compound, duplex Hughes pumps of 1,000 000 gallons capacity each, erected in 1890 with the works. The standpipe is 105 feet high, 20 feet in diameter and it has a capacity of 247,000 gallons. It has not been cleaned since erected.

There are about 11 miles of mains, giving about 60 per cent. of the population access to the water. There are 700 services of which 630 are in use and none of these metered. The average daily consumption is about 800,000 gallons and the average per consumer is 210 gallons.

The annual water rates are as follows:

Private houses, six rooms or less	$6 00
" " each additional room	75
" " each additional family	6 00
" bath tubs, each	3 50
" water closets, each	4 00
" stables, one horse	3 00

The city water is used by about one-half of the city for domestic purposes, the other half using private well water. The wells are dug and from 10 to 20 feet deep, the water being found in a stratum of quicksand or gravel at this depth.

Sewerage—Conneaut has the separate system of sewers, or rather a sanitary system as nearly all the storm water is carried off in surface drains. There are about six miles of sanitary sewers in the main portion of the city and one-fourth of a mile down in the harbor portion. These sewers have two outlets to Conneaut creek which empties into the lake at the harbor. The main street has a storm sewer emptying into the same stream. It is estimated that the sewers give some 60 per cent. of the population access to them There are 219 water closet connections to the sewers, representing about 1,500 people. The sewage causes no nuisance but, as in all the lake towns, there is a liability of its polluting the water supply. Vaults are but little used, surface privies being the rule. Night-soil is buried back in the country. Garbage is carried to the city dump one-half mile above the town near Conneaut creek.

LORAIN, Lorain county, population 15,000. The growth of this city has been very rapid, so fast that the public improvements have in no way been able to keep pace with it. Its industries consist of a large steel plant,

ship yard, railroad shop, ore and coal handling, and a great deal of general shipping and manufacturing. Lorain has a number of paved streets, a few sewers and a water supply. The population includes a large foreign element from the steel works and docks, making sanitary improvements difficult.

Water Supply—The water works were put in by the city in 1884, and have cost to date $230,000. The supply is from a submerged crib in Lake Erie, 1,200 feet from the shore and a little west of the outlet of Black river. The sewage of both Elyria and Lorain empties into this river and this in turn frequently flows over the intake. The water became so bad that a Jewell mechanical filter plant was introduced in 1897, and has been in operation ever since, with great improvement in the quality of the water. Elyria, population, 8,252, is situated at the junction of the two forks of the Black river, seven miles from its mouth. The sewage of about 2,500 people is emptied directly into the river at this point. The population of Lorain having the use of the sewers is estimated at 4,000.

The water flows from the crib to a pump well, from which it is forced to the filters, passes down through them by gravity to a clear water basin, from which it is pumped direct to the mains. There are three pumps in use now, with a fourth one just being installed. They are as follows: A horizontal, duplex Walker pump of 1,000,000 gallons capacity, put in in 1884; a horizontal, compound, duplex Gordon pump of 2,000,000 gallons capacity, put in in 1892, a horizontal, compound, duplex Holly pump of 5,000,000 gallons capacity put in in 1896, and a new horizontal, compound, duplex Holly of 5,000,000 gallons capacity, just being installed. The new Holly pump and the Gordon pump are connected up, so that they can supply the filters or pump direct to the mains. The old Holly can pump to the mains only and the Walker can pump to the filters only.

The filter plant consists of a set of six standard Jewell gravity filters, with a total capacity of 3,000,000 gallons. The filter tubs are each 17 feet in diameter, with an effective filter area of 226 square feet and a total of 1,356 square feet. The filter bed is four feet deep and is composed of a smooth, round-grained, white sand, from Red Wing, Minnesota. Before the water passes to the filters a certain amount of coagulant, sulphate of alumina, is added to it; the water then enters a small settling basin in the lower part of each filter tub, then passes upward through a standpipe in the center of the filter, spreads out over the surface of the sand, passes down through the latter and is collected in a network of pipes, to which are attached small strainers. The water then passes to a large, clear water well, formed by the foundation walls of the filter house. The suction of the pumps which supply the city is connected direct to this basin. The rate of filtration is controlled by a float operating the outlet valve.

When the filter becomes clogged the sand is washed. The piping is so arranged that the flow can be reversed and filtered water forced up through the sand, which at the same time is agitated by a mechanical stirrer. The filters must be washed from two to three times a day, using about 8,000 gallons of filtered water for each washing. The plant was approved by the State Board of Health, with the condition that at least 2.5 grains of alum should be used with each gallon of water, and that the rate of filtration should not exceed 100,000,000 gallons per acre per day. This would give the plant a capacity of 3,110,000 gallons, a little more than the rated capacity. The above were the figures which gave the best results in the test of the plant by the Board, for the details of which see the annual report of the State Board of Health for 1897. Since the approval of the plant the condition as regards the amount of coagulant used has hardly been observed at all. For 30 days, in September, 1897, no alum at all was used. From December 16, 1897, to June 6, 1898, lime was used in connection with the alum; the quantities averaged about 0.90 grains of alum and 0.80 grains of lime per gallon. During the summer of 1898 the alum varied from 0.7 to 1.5 grains per gallon, and in the winter of 1898 the quantity was increased to 1.5 to 2.0 grains.

There are 25 miles of mains, giving about 95 per cent. of the population access to the water. There are 2,979 services, of which 2,713 are in use and 40 of those are metered. The average daily consumption is 2,583,000 gallons and the average per consumer is 185 gallons.

The annual water rates are as follows:

Private houses per family	$8 00
" bath tubs, each	3 00
" water closets, each	3 50

The city water is used almost entirely for domestic purposes, as there are but one or two private wells in Lorain. Filtered cistern water is drunk to a limited extent.

Sewerage—Lorain has 8 4 miles of combined sewers and 4.1 miles of separate sewers. The separate system is located in the new addition around the steel plant. The separate and combined sewers have each one outlet to Black river, but the latter also have three storm water overflows to the same stream. The sewage causes no nuisance but as explained above, it may at times pollute the water supply. There are about 700 connections to the sewers, most of which are for closets. Vaults are usually constructed of brick and are fairly water-tight. Many use plank boxes, making a half way dry earth closet. Night-soil and garbage are hauled to the country and disposed of.

PORT CLINTON, Ottawa county, population 2,624. Port Clinton, the county seat of Ottawa county, is a pleasant little village situated at the mouth of the Portage river. It is supported entirely by its fisheries and its neighboring farmers. It has a water supply, some sewers, and about 1.9 miles of paved streets.

Water Supply—The water works were put in by the village in 1896, and have cost to date $41,025.76. The supply is from Lake Erie through a 16-inch pipe leading to a crib 1,600 feet from the lake shore and about 1,000 feet west of the mouth of the river. The crib consists of two timber shells, the outer 30 feet square and the inner 12 feet square, with the intervening space filled with gravel, through which the water must percolate before reaching the intake pipe, the end of which is placed five feet above the bottom of the lake. The water is pumped direct to the mains by two horizontal, compound, duplex Laidlow-Dunn-Gordon pumps of 1,000,000 gallons capacity each. There are seven and one-half miles of mains, giving practically the whole population access to the water. There are 225 services, of which 220 are in use, with none metered.

The average daily consumption was estimated at 500,000 gallons, but this is much too large, as 200,000 would be a high figure for a town of this size and class.

The annual water rates are as follows:

Private house, one family	$4 00
" bath tubs, each	2 00
" water closets, each	2 00
" stables, one horse and carriage	2 00

The hydrant water is used almost entirely for domestic purposes, as there are but few private wells in town. The few in use are only 14 feet deep, obtaining their water just above a layer of hard-pan. A few families drink cistern water.

Sewerage—Port Clinton has three miles of combined sewers, with four outlets direct to the Portage river. There are quite a number of connections to the sewers, but only 57 are for water closets. The sewage causes no nuisance, but, as in most of the lake towns, the purity of the water supply depends upon the constancy of the easterly currents. Vaults are constructed of plank, none of them being water-tight. Night-soil and garbage are removed to the dump ground, located one and one-half miles southwest of town, near the Sandusky bay.

The report upon Sandusky will be found with the special report upon the Sandusky watershed.

(*d*) WELLS AND GALLERIES SUPPLIED BY SURFACE WATER.

GALLIPOLIS, Gallia county, population 4,588. Gallipolis, the county seat of Gallia county, is a typical river town of the older class, and has but little manufacturing. One of the large State hospitals is located there. The town has some paved streets, an electric car line and a water supply, but no sewers.

Water Supply—The water works were put in by the village in 1895, and have cost to date $90,000. The supply is from filter wells in the bed of the Ohio river. There are four wells, each 4 feet in diameter and 6 feet deep and open only at the bottom, which is 13 feet below the low water mark of the river. The wells are placed in a sandbar at the head of Gallipolis island, and the depth of their bottom below the bed of the river varies with the shifting of the sand. The wells are made of cast iron and each is joined by a 12-inch pipe to a common suction pipe, which is 16 inches in diameter and 1,600 feet long. The pumps are connected direct to this pipe. The wells are above all local pollution of the river and 15 miles below Pomeroy and Middleport. These two towns have few sewers and the river receives nothing but the surface drainage. The water is pumped from the wells to a reservoir by two vertical, compound, duplex, condensing Gordon pumps of 720,000 gallons capacity each. The reservoir is 280 feet long, 85 feet wide, 15 feet deep, and has a capacity of 2,300,000 gallons, and is 324 feet above the bottom of the pump pit. The reservoir is quarried out of the rock, the sides are bricked up and the bottom concreted. A by-pass at the station allows the water from the reservoir to flow back through the suction pipe and wells so as to clean out the sand and gravel near the wells when it becomes clogged with silt. The wells furnish a satisfactory water and so far a sufficient quantity. There are 9.7 miles of mains, which give some 95 per cent. of the population access to the water. There are 489 services, of which 460 are in use, and 100 of these are metered. The average daily consumption is 350,000 gallons, of which 110,000 are used by the epileptic hospital. This leaves 240,000 gallons for the city, or an average per consumer of 90 gallons. The hospital has 900 inmates, and the average consumption for each person is 122 gallons. The hospital is trying to secure a separate supply.

The annual water rates are as follows:

Private houses, six rooms or less	$4 00
" " each additional room	50
" bath tubs, each	3 00
" water closets, each	2 00
" stables, one horse and carriage	2 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per month	35
One thousand five hundred to 3,000 gallons per month	25
Above 20,000 gallons per month	10

Where the tap water is available it is used for domestic purposes. It is estimated, however, that fully three-fifths of the population depend, for this use, upon cistern water. There are but few private wells, and these but little used.

Sewerage—Gallipolis has no sewers. The storm water is carried to the Ohio river through surface drains and a few tiles. Every house has a vault or cesspool, constructed without rule. None of them are ever cleaned out. When they become full new ones are dug beside them Garbage is dumped over the river bank.

The hospital has a complete system of sewers, the outlet of which is Mill creek, which empties into the Ohio river just above town. The outlet of the sewer is about 300 yards from the mouth of the creek. This creek is perfectly dry for the greater part of the time so that the sewage lies in pools and decays, giving off very offensive odors. Every rain washes this sewage down into the river, just above the water works station but below the wells, which are 1,600 feet above the pumping house. The village objected to having the hospital sewer carried into the river, as there is a great deal of water hauled from the wharf. The present arrangement holds a greater part of the sewage back until a heavy rain comes, when it is all washed into the river.

GREENFIELD, Highland county, population, 2,831. This is a quiet little village with no manufacturing whatever. It is supported by the country around it and the few limestone quarries near at hand. Greenfield has a water supply, and electric lights, but no paved streets or sewers.

Water Supply—The water works were put in by the village in 1891 and have cost to date, about $40,000. The supply was originally from Paint creek direct, but in 1893 the creek dried up and a well was dug in the bed of the creek so as to get the ground flow. The well is constructed of brick and is 24 feet in diameter and 15 feet deep. The water stands at the creek level when not being pumped, and is lowered about three feet during pumping. Direct connection can be made to the creek in case of fire. There is a dam just above the water works which impounds the water for power purposes. It is 250 feet long, seven feet high and backs the water up about one-half mile. The extreme width of the creek here is due to a large island. Eight miles above the water works there is another dam 225 feet wide and six feet high, backing the water up about three-fourths of a mile. The local pollution of the creek consists of the large

cemetery just above the water works, the dirty surface drainage of the upper part of town, and the drainage from the small village of Goodhope, some seven miles up the creek. The water is pumped from the wells to a standpipe by two, horizontal, duplex, Gordon pumps, of 750,000 gallons capacity each. The standpipe is 75 feet high and 14 feet in diameter, with a capacity of 85,000 gallons. It is located on a hill 50 feet above the city hall. There are nine and one-quarter miles of mains, giving some 85 per cent. of the population access to the water. There are 210 services in use, five of which are metered. The average daily consumption is 300,000 gallons, and the average per consumer is 200 gallons. There is no regular list of rates, the price being estimated for each house.

The private well supply is principally from dug wells, which get their water just above the limestone, some 10 to 25 feet down.

Sewerage—There are a few storm sewers leading from the center of the village to the creek. They have about twenty closet and vault connections. One of these sewers empties just below the water works and is liable to pollute the supply during low water. A dam one foot high and 150 feet long, some distance below the water works, backs the water nearly to the well and holds the sewage, causing some nuisance. A number of outhouses built over the creek makes the latter somewhat objectionable. Vaults are not regulated in any manner.

PAINESVILLE, population 5,762; FAIRPORT, population 1,000; RICHMOND, population 300; Lake county. These towns are practically one as far as location is concerned. Painesville corresponds to the business portion of the other lake towns, and Fairport and Richmond correspond to the harbor portion. Painesville has a little general manufacturing, but is supported principally by the industries at the harbor. It has an electric car line to Cleveland, which gives it a rather suburban life. Fairport and Richmond have a large floating population depending upon the work at the docks and elevators, which are the life of both places. These three towns have the benefit of a water supply, which for Fairport and Richmond constitute the only public improvements, while Painesville has a few paved streets and a fair sewer system.

Water Supply—The water supply was put in by a private company in 1882, and has cost to date about $260,000. In 1897 the city of Painesville purchased the plant for $150,000, owing to the great depreciation of the same. The first supply was from wells and springs, but these were abandoned in 1891, when the present system of galleries was perfected. The sole supply now is from galleries in the sandy shore of Lake Erie. They are located some distance west of the outlet of Grand river. These galleries consist of plank boxes 14 inches high, 20 inches wide, and 8

feet long, placed end to end in long rows. The sides of the boxes are left open except for a wire screen to keep out the sand and gravel. Around these boxes is placed a layer of gravel, coal and charcoal, about two feet thick. Over this the lake sand is allowed to drift and wash. These galleries have to be placed just under the edge of the water so that the wave action will keep the sand washed clean. At the site of the galleries the beach is building, and two galleries have had to be abandoned and new ones built as the beach extended. In all, 1,700 feet of galleries have been built, only 1,100 feet of which can now be used. The water enters the galleries, flows from there to a raceway or reservoir, and is then pumped through the mains to a standpipe. The raceway is nine feet wide and 400 feet long, the water standing about six feet deep in it, the level of the lake. It is built of plank and covered with the same to keep the sand out.

The pumps, two horizontal, compound, duplex, Knowles of 1,500,000 gallons capacity were installed in 1891, when the pumping station was moved down to the lake shore. The standpipe is 25 feet in diameter and 75 feet high, giving a capacity of 275,000 gallons. The top of the standpipe is 235 feet above the lake level and gives a domestic pressure in Painesville of about 40 pounds.

In the three towns there are sixteen miles of mains, giving about 90 per cent. of the total population access to the water. In all, there are 1,000 services in use, divided as follows: Painesville 820, Fairport 150 and Richmond 30. Four services in Painesville are metered.

The average daily consumption is 1,250,000 gallons, of which some 130,000 gallons are used daily by the three railroads. This gives an average daily consumption of 187 gallons per consumer.

The annual water rates are as follows:

Private houses, five rooms or less	$5 00
" " each additional room	1 00
" " each additional family	5 00
" bath tubs, each	4 00
" water closets, each	4 00
" stables, one horse	5 00

The city water is in general use where it is available. Private wells are mostly dug and from 15 to 20 feet deep. The water is found in sand and gravel.

Sewerage—Painesville has about ten miles of sanitary sewers with three outlets to Grand river. One of the sewers carries some storm water, but most of it is carried off in surface drains. It is estimated that about 75 per cent. of the population has access to the sewers, and that one-half of these have connections. This agrees very well with the direct

estimate of four hundred as the number of sewer connections; three hundred being for water closets. The sewage causes some nuisance during extremely low water, but it does not pollute the water supply in any way. There are but few vaults in use, surface privies being the most common. Night-soil is buried in the country and garbage is dumped in a field just north of the city.

Richmond and Fairport each have a few private sewers, but no general system.

RIPLEY, Brown county, population 2,824. Ripley is a quiet little village of the older river type. It has no manufacturing, and is supported by the small shipping industry and by the neighboring farmers. It has a water supply which constitutes the only public improvement.

Water Supply—The water works were put in by the village in 1896, and have cost to date about $24,000. The supply is from two wells on the bank of the Ohio river. These wells are eight inches in diameter and 102 feet deep, 40 feet of which is in sand and gravel and 62 feet in limestone. The wells are pumped to two settling basins by a Hall Pump Company air lift. The level of the water in the wells is the same as that in the river, and is lowered but little by the pumps. The air lift was made necessary by the wide fluctuation in the level of the water due to the varying stage of the river. The settling reservoirs are each 93 feet in diameter, and eight feet deep, giving each a capacity of 500,000 gallons. The sides and bottom are built of brick laid in cement. They are cleaned out two or three times each year, a large amount of moss and other growths being removed each time. The water tastes and smells if left in the basins long. Most of the water comes from the gravel bed which is supplied by the ground water on its way to the river, and by the subsurface flow of the latter. The water is pumped from the basins to a distributing reservoir, on a hill back of town, by a horizontal, compound, duplex Hall pump of 500,000 gallons capacity. This reservoir is built in the same manner as the settling basins, and has a capacity of 1,000,000 gallons. It gives a pressure of 140 pounds on the streets. There are four miles of mains, giving about 60 per cent. of the population access to the water. There are 130 services in use, of which 36 are metered. The average daily consumption is 180,000 gallons, and the average per consumer is 225 gallons.

The annual water rates are as follows:

Private house, six rooms or less	$5 00
" " each additional room	50
" water closets, each	2 50
" bath tubs, each	2 50
" stables, one horse and carriage	3 00

By meter, from 5,000 to 25,000 gallons per month, 20 cents for first 5,000 gallons and 6 cents for each 1,000 thereafter.

The private water supply is from a few dug and drove wells, the former about 40 feet deep and the latter from 80 to 90 feet deep. Cistern water is used almost entirely for domestic supply.

Sewerage—There are a few private sewers to the river and a number of storm water drains. It is estimated that forty houses have access to the private sewers. Vaults are not regulated in any manner, beyond requiring them to be cleaned. Night-soil is buried in the country.

WILLOUGHBY, Lake county, population 1,455. This is a quiet country village with but little manufacturing. It has an electric car line to Cleveland, which gives it some value as a residence place. Willoughby has a public water supply, but no sewers or paved streets.

Water Supply—Water works were put in by the village in 1892, and have cost to date about $32,000. The supply is from an infiltration well in a gravel bed some fifty feet from the bank of the Chagrin river. The water is pumped to a reservoir 180 feet above the river level by two horizontal, compound, duplex Hughes pumps of 500,000 gallons capacity. The reservoir is built of brick laid in cement and is covered with a conical board roof. It has a capacity of 800,000 gallons. There are five miles of mains, giving some 90 per cent. of the population access to the water. There are 250 services, with 200 in use and none metered. The average daily consumption is about 100,000 gallons, and the average per consumer is 83 gallons.

The rate for private families is $5 per year.

The water is in general use where available. It is estimated, however, that about 50 per cent. of the population use well water for drinking purposes. The wells are dug and about 20 feet deep, obtaining their water in an extensive bed of gravel.

Sewerage—Willoughby has no sewerage except a few short storm water drains. It is claimed that there are no vaults in use, every one using the dry earth closet, or a modification of it. Night-soil is usually hauled to farms. Some is buried at any available place.

2. SUBSURFACE WATER.

GALLERIES AND WELLS SUPPLIED BY SUBSURFACE WATER.

The report upon the water supply of Attica will be found with the special report on the Sandusky watershed, and the report upon the Wadsworth water supply is given in a special report with this volume.

ASHLAND, Ashland county, population 4,160. Ashland, the county seat of its county, is situated near the headquarters of Jerome fork, a secondary branch of the Muskingum river system. It is a country town with some general manufacturing. It has a few paved streets, a water supply, but practically no sewers.

Water Supply—The water works were put in by the village in 1895, and have cost to date some $50,000. The supply is from two wells situated between the branches of Jerome creek and one-half mile east of the corporation. One of the wells is 30 feet in diameter and 16 feet deep; the other 36 feet in diameter and 18 feet deep. The former was dug in 1895 and the latter in 1896. They are built of brick and covered with a conical roof and fully protected from surface drainage. The water is found in a bed of gravel, in which during wet weather it rises to the surface and in dry seasons falls to within a few feet of the bottom of the wells. The water is pumped from the wells to a standpipe by two horizontal, compound, duplex Smith-Vaile pumps of 1,000,000 gallons capacity each. The standpipe is 20 feet in diameter and 75 feet high, giving a capacity of 176,000 gallons. The pressure on the main street is 75 pounds and at the station 122 pounds. There are 13 miles of mains in, giving 65 per cent. of the population access to the water. There are 355 services in and 351 in use, of which 10 are metered. The average daily consumption is 125,000 gallons and the average per consumer is 60 gallons.

The annual water rates are as follows:

Private houses, six rooms or less	$3 50
" " each additional room	50
" bath rooms, each	3 00
" water closets, each	3 00
" stables, one horse and carriage	3 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	$0 20
One thousand to 2,000 gallons per day	14
Five thousand to 10,000 gallons per day	8

The water is high in mineral matter, forming a soft deposit in boilers and heaters, which also contains a large amount of carbonaceous matter. The water is not objectionable except in summer, when it becomes warm, then private well water is used to a large extent for domestic purposes. The wells vary in depth from 13 to 60 feet, the shallow ones obtaining their water in a bed of gravel, which is exposed to surface contamination, while the deeper ones obtain the water from a bed of limestone 24 feet down, which is overlaid with a bed of shale.

Sewerage – Ashland has but three short sewers. These carry off the storm water and kitchen refuse, and it is claimed some sewage. They empty within the corporation into a small branch of Jerome creek. The oil and soap from one of the machine shops drained by the sewers causes a nuisance in the summer.

Vaults are not regulated in any way, and many are not cleaned as often as necessary.

CIRCLEVILLE, Pickaway county, population 7,524. This town, the county seat of Pickaway county, is in the center of a famous farming district, the "Pickaway Plains." It is supported largely by the surrounding country, but it also has some general manufacturing, including a large strawboard works. Circleville has a water supply and a few paved streets, but no adequate sewer system.

Water Supply—The water works were put in by a private company in 1887, and have cost to date $150,000. A franchise was granted a company in 1886, but this one failed after building the plant, but before it was put in operation. The present company then gained control and put the works in operation, after making several additions and changes. The franchise is to run for 20 years from August 9, 1886, and contains this clause in reference to the kind of water to be supplied: "The water shall be taken from wells or filtering galleries sunk as near Hargus creek or Darby creek as an investigation may hereafter determine, together with such reservoir or storage basins of not less than 10,000,000 gallons capacity; but before such wells or filtering galleries shall be located, test wells must be sunk at various points and the water therefrom or from the stream from which it is taken submitted to an analysis by some competent person selected by the city council and Samuel R. Bullock & Company, at the expense of said council and company co jointly, after said wells or well have been definitely located. They are to be so ar-

ranged as to exclude all surface water and any overflow from either of said creeks, and to be of sufficient capacity to allow when necessary the water to settle before being pumped into the reservoir or standpipe as the case may be; said wells are to be provided with such filtering galleries and wells as may be necessary to insure the entire supply to be clear water, suitable for culinary and drinking purposes and not detrimental to health, the quality and character of said water to be kept and maintained as shown by the analysis. Should at any time the quality of the water deteriorate and become impure, other wells are to be sunk and water obtained from such other sources as an analysis show to be pure and wholesome." It also states that no water shall be taken directly or indirectly from the Scioto river. The plant may be purchased by the city at any time after the expiration of ten years.

The present source of supply is a gallery near Big Darby creek, northwest of town. The gallery is a brick conduit running parallel to the creek and about 100 feet distant. It is 200 feet long, five feet wide and five feet high, with an arched top and terminates in a covered brick well 25 feet in diameter and 30 feet deep. The gallery enters the well a few feet above the bottom.

A small dam, 18 inches high and 100 feet long, in Big Darby creek backs the water up about one-fourth of a mile, giving a pond area of some four acres. This dam was put in by the first company and a 6-inch pipe led from the creek above it to the receiving well. This pipe was to be used in cases of emergency, but it has since been washed out. Farther up a dam diverts part of the creek to a race, which empties into the canal below town. This dam is five feet high, 100 feet wide and backs the water up about one mile.

The water is pumped from the receiving well to a standpipe by two horizontal, compound, duplex Holly pumps of 1,500,000 gallons capacity each. The standpipe is 150 feet high and 22 feet in diameter, with a capacity of 425,000 gallons. There are 15 miles of mains, giving some 90 per cent. of the population access to the water. There are 859 services, of which 750 are in use and 75 of these are metered. The average daily consumption is 600,000 gallons and the average for each consumer is 130 gallons.

The annual water rates are as follows:

Private houses, six rooms or less	$6 00
" " each additional room	75
" bath tubs, each	.....
" water closets	2 00
" stables, one horse and carriage	2 50

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	$0 30
One thousand to 2,000 gallons per day	23
Over 4,000 gallons per day	15

The private water supply is from dug wells, about 25 feet deep, which obtain their water from an extensive bed of gravel under the town. The tap water is used where available, but one-third of the population are dependent upon wells.

Sewerage—The sewers of Circleville, so far as they go, are on the separate plan. There is about three-fourths of a mile of sanitary sewer, with one outlet to the Scioto river and the same length of storm sewers, with one outlet to Hargus creek. The sanitary sewer has a few closet connections, but the amount of sewage is small as compared with the flow of the river, and no nuisance results. The storm water is carried in part to Hargus creek by the storm sewer and gutters, and the remainder to the Scioto river and the canal through surface drains. As the sanitary sewer has but few connections as yet, nearly every one must use outdoor vaults. These are usually constructed of brick, but not made water-tight. Night-soil is hauled to the country.

The pollution of the Scioto river below Circleville is marked. In addition to the small amount of sewage the local gas plant and a large strawboard works send their refuse direct to the river. The strawboard works is an immense plant, employing a large number of men and turning out car loads of strawboard daily. The refuse from this plant reaches the river through two sewers, each two feet in diameter. One of these sewers empties into some low bottom land near the river, which originally served as a settling basin and precipitated most of the heavy matter from the waste water before the latter passed to the river. Now this basin is almost completely filled with sediment, and the effluent from the works has kept a channel open the whole length of the bed along which it now flows to the river with but little sedimentation. This basin contains about 15 acres, the whole of which, except for the narrow channel near one side, is filled from one to 10 feet with a decaying mass of organic matter. This mass gives off bubbles of gas continually and is very offensive. Large quantities of this accumulated filth are washed into the river during hard rains, as may be seen from the high mark of the drift. The other sewer empties into a ditch, which runs alongside the river and empties into it about one-fourth of a mile below the works. The flow of these two sewers amounted at time of inspection to over five cubic feet per second or about 4,000,000 gallons per day, and the amount was sufficient to color the river a bright yellow. It is fortunate that the

river below this point is not called upon to furnish a water supply, as this large amount of organic matter effectively destroys for many miles its usefulness for any such purpose.

GREENVILLE, Darke county, population 8,176. This city is the county seat of Darke county. Its industries consist of a couple of small tile yards, a saw mill and a machine shop. Greenville has electric lights, a water supply and a few sewers, but no paved streets as yet.

Water Supply.—The water works were put in by the city in 1893, and have cost to date about $89,000. The supply is from nine wells, six inches in diameter and from 50 to 57 feet in depth. The wells go through gravel and clay into a bed of gravel. The water rises nearly to the surface when the wells are not being pumped, and during a test it was lowered 18 feet, at which depth pumping at the rate of 900,000 gallons per day failed to lower the water farther. The water works is west of town on Greenville creek, to which direct connection can be made in case of fire, but this connection has not been used since August, 1895. There is a mill dam on Greenville creek, 1½ miles above the water works, which controls the amount of water in the creek during dry weather. It is six feet high, 40 feet long and backs the water up about 1½ miles.

The water is pumped direct from the wells to a standpipe by two horizontal, compound, duplex, condensing Hughes pumps of 1,500,000 gallons capacity. The standpipe consists of a tank 60 feet high and 20 feet in diameter, placed on a brick tower 70 feet high. It has a capacity of 141,000 gallons. There are 13 miles of mains, giving 90 per cent. of the population access to the water. There are 497 services and 447 in use, of which 169 are metered. The average daily consumption is 200,000 gallons and the average per consumer is 75 gallons.

The annual water rates are as follows:

Private houses, seven persons or less	$4 00
" " each additional person	25
" bath tubs, each	3 00
" water closets, each	2 00
" stables, one horse and carriage	1 50

The meter rate is 10 cents per 1,000 gallons, with minimum charges for the different sized meters.

Private wells are usually dug and from 14 to 35 feet deep.

Sewerage—There are about four miles of storm sewers in Greenville, with three outlets direct to Greenville creek, one to a ditch emptying into Mud creek and one to a ditch emptying into Bridge creek. One sanitary sewer empties into Greenville creek. These sewers have about a dozen closet connections, but the small amount of sewage causes no nuisance.

Vaults are required to be water-tight, but very few of them are. Night-soil is hauled to the country. A slaughter house on Greenville creek sends all its waste to that stream. The creek has a murky, greasy appearance, showing that the stream is getting about all the sewage that it can dispose of without causing a nuisance.

HILLSBORO, Highland county, population 4,000. Hillsboro, the county seat of Highland county, is a country village with but little manufacturing. It has a water works and a few paved streets, but no sewer system.

Water Supply—The water works were put in by the village in 1893, and have cost to date about $90,000. The supply is from 10 wells, six inches in diameter, and from 45 to 50 feet deep. They are sunk into the gravel bed of Clear creek, north of the village. The water rises in the wells to within five feet of the surface and can be pumped down to the suction limit. The water is pumped to a standpipe by two horizontal, compound, duplex Laidlow-Dunn-Gordon pumps of 1,000,000 gallons capacity each. The standpipe is 135 feet high and 15 feet in diameter, with a capacity of 175,000 gallons. There are 10⅓ miles of mains, which give about 75 per cent. of the population access to the water. There are 474 services in use, 43 of which are metered. The average daily consumption is 125,000 gallons and the average per consumer is 50 gallons.

The annual water rates are as follows:

Private houses, five rooms or less	$4 00
" " each additional room	50
" bath tubs, each	2 50
" water closets, each	2 50
" stables, one horse and carriage	2 50

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	30
One thousand to 2,000 gallons per day	23
Above 4,000 gallons per day	15

The private water supply is from dug wells about 30 feet deep, obtaining their water in the loose limestone, which is found just below the surface.

Sewerage—The surface drainage is to small ditches leading to both Clear and Rock Fork creeks. There is one sewer that leads to a branch of Clear creek. Several business blocks, the court house, jail, hotel and a laundry are connected to this sewer, which empties first into a large cesspool 20 feet square and 12 feet deep, from which the water is siphoned to the creek. This sewer has caused considerable complaint, but at the time

of inspection was causing no nuisance. Vaults must be 50 feet from wells or be water-tight, but these regulations are not enforced.

KENTON, Hardin county, population 7,598. Kenton, the county seat of Hardin county, is situated near the head waters of the Scioto river and right on the State divide, part of the surface drainage of the city going north to the Blanchard river. The industries consist of a number of small plants engaged in the manufacture of hardware and implements, a car shop and the usual elevators, flour mills and lumber yards. It has a number of well paved streets, some sewers and a water supply.

Water Supply—The water works were put in by a private company in 1883, and were purchased by the city in 1887. The plant has cost to date $120,000. The present supply is from a large basin excavated from 30 to 90 feet into the limestone rock, which comes nearly to the surface at this point. This well is in the southern part of the city and 300 feet south of the Scioto river. It seems to be supplied with ground water on its way to the river, or at least by water from the vicinity, as the level of the water in the well is influenced by the local rainfall. The basin is 240 feet long and 40 feet wide; one end 40 feet square is 90 feet deep and the remaining portion is only 30 feet deep. The well has no walls except the natural stone; it is surrounded by a high fence and a slight embankment, so that it suffers but little from surface pollution. In the bottom of the basin six wells have been drilled; these are 150 feet deep from the surface and six inches in diameter. As these wells furnish but little water now, it was thought best to place Kenton in the class supplied from subsurface sources.

The water is pumped from the wells direct to the mains by the folowing pumps: Two horizontal Holly pumps of 500,000 gallons capacity each, so arranged that they can be connected and run as a 1,000,000 duplex pump; and a quadruplex Holly pump of 1,500,000 gallons capacity Both of the above were put in in 1883, and a small duplex McGowan pump of 250.000 gallons capacity, installed in 1894. The pumps are all placed 30 feet below the surface and the suction 26 feet farther down. In summer the water is lowered to within a few feet of the suction and in winter it rises as high as 22 feet above it.

There are about 12 miles of mains in, giving some 50 per cent. of the population access to the water. There are something over 600 services in use, there being some in use, but not recorded; 13 services are metered. The average daily consumption is about 650,000 gallons and the average per consumer is 162 gallons.

The annual water rates are as follows:

Private houses, per family	$4 00
" bath tubs, each	4 00
" water closets, each	4 00
" stables, one horse and carriage	4 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	25
One thousand to 2,000 gallons per day	15
Over 3,000 gallons per day	10

The city water is not in general use on account of the uncertainty of the supply. It is estimated that 80 per cent. of the population depend upon private wells for the domestic supply. The wells are all depths and descriptions, most of them are dug, however, from 10 to 50 feet deep; some of the drilled wells are 100 feet deep. The water is obtained in sand and gravel under the surface soil; some of the deeper ones get the water from the limestone or just above it.

Sewerage—Kenton has no adequate sewerage, the system being put in a piece at a time. There are six miles of combined sewers and three-fourths of a mile of storm sewers, all emptying into the Scioto river The sewers cover the central portion of the city only, the outskirts having but little access to them. Both vaults and water closets are connected to the sewers, but the number cannot even be estimated. The sewage causes a nuisance during low water, but does not pollute the water supply. Vaults are usually constructed of brick, but very few of them are water-tight. Night-soil is hauled to the farms. Garbage is dumped in an old railroad cut near the river.

LANCASTER, Fairfield county, population 8,302. Lancaster, the county seat of Fairfield county, is situated on the head waters of the Hocking river. Its principal industries are the shoe factories and agricultural implement works. It has many well paved streets, a fair sewer system and a water works.

Water Supply—The water works were put in by the city in 1879, and have cost to date $104,024.84. The first supply was from the old Hocking canal and was used for fire purposes only. The present supply is from a gallery, and was introduced in 1881. The gallery is constructed of brick and is 1,100 feet long, with a cross section $3\frac{1}{2}$ by $3\frac{3}{4}$ feet. It lies in the lowland between the Hocking river and the old Hocking canal. The principal portion of the city is situated on the high land back from the river, so that the water obtained by the gallery is chiefly the underdrainage of the city. The old canal bed is higher than the gallery, and is at present serving as a dumping ground. Two 2-foot tile sewers are carried under the canal and over the gallery, one being carried to the river 200

yards past the gallery and the other stopping 32 feet on the other side of the gallery. The sewage from the sewer collects in a large pool from lack of drainage, causing a horrible nuisance, and without question seriously polluting the ground water with which the gallery is supplied. The gallery is about 11 feet under ground, built in a bed of gravel overlaid by blue clay. This rather impervious covering is the only thing which protects the ground water from the grossest pollution. The gallery leads to a brick well 18 feet in diameter and 20 feet deep, from which the water is pumped to a reservoir by two horizontal, duplex Worthington pumps of 1,500,000 gallons capacity each. One pump was put in in 1881, and the other in 1894. The water stands at times as high as eight feet from the bottom of the well, and can be lowered to within three feet of the bottom. The reservoir has just been completed; it is situated on top of a hill one mile east of town. It is constructed of stone laid in cement and is 100 feet wide, 220 feet long, 18 feet deep from the coping and has a capacity of 2,430,000 gallons. It is not covered, but its location prevents all surface contamination.

There are a little over 13 miles of mains in, giving some 80 per cent. of the population access to the water. There are 625 services in, of which 600 are in use and 10 of these metered. The average daily consumption is 350,000 gallons and the average per consumer is 97 gallons.

The water rates have just been changed and the new ones are not available.

A large majority of the city's population use well water for domestic purposes. The wells are both dug and drove, but all are about 30 feet deep and obtain the water in a bed of gravel which underlies the whole region. Owing to the poor sanitary arrangements, the well water is very liable to pollution.

Sewerage—Lancaster has the combined system of sewers, with outlets to the Hocking river. The sewers are of piece meal construction and are in poor condition. Not all the outlets are carried to the river and these cause considerable nuisance, and, as mentioned above, pollute the water supply. Vaults and cesspools are connected to the sewers, but the number could not be learned. Vaults are very poorly constructed, some of plank and others of brick; none are water-tight. In some cases old wells have been used as cesspools. Night-soil and garbage are dumped one-half mile below town.

NELSONVILLE, Athens county, population 6,475. This is a manufacturing and mining town. The principal industries are the brick and tile yards and coal mining. It has some paved streets, electric lights, sanitary sewers and a water works.

Water Supply—The water works were put in by the city in 1894, and have cost to date $40,000. The supply is from a well 30 feet in diameter and 23 feet deep. The water is obtained from a bed of sand and gravel, which is supplied to some extent with water from the Hocking river, a couple of hundred yards distant. The well is not wholly free from pollution, as there are a number of houses close to it, which are liable to contaminate the ground water with the leakings from their dirty yards and vaults. The well is constructed of brick and covered with a conical board roof. At times the water rises nearly to the surface, depending upon the rainfall and the height of the river, and it can be lowered to the strainer, which is four feet above the bottom. The ground water is kept up to some extent by a dam in the Hocking river, just below the water works. The dam is eight feet high, 300 feet long and backs the water up about three-fourths of a mile.

The water is pumped from the well to a reservoir by two horizontal, compound, duplex Gordon pumps of 750 000 gallons capacity each. The reservoir is 240 feet above the pumps and the same distance above the city, which it supplies by gravity. This reservoir is 80 feet in diameter and 22 feet deep, with a capacity of 750,000 gallons. It is constructed of brick laid in cement and is covered with a tin roof. It is cleaned once a year, a small quantity of sediment being removed each time There are eight miles of mains in, giving some 95 per cent. of the population access to the water. There are 230 services in use, of which three are metered. The average daily consumption is 130,000 gallons and the average per consumer is 95 gallons.

The annual water rates are as follows:

Private houses, each family	$4 00
" " each additional family	3 00
" bath tubs, each	3 00
" water closets, each	3 00
" stables, one horse and carriage	3 00

Meter rates per 1,000 gallons:

Less than 500 gallons per day	30
One thousand to 2,000 gallons per day	20
Over 10,000 gallons per day	8

Where the tap water is available it is used for domestic purposes. The private water supply is from dug wells, usually 30 feet deep, which go through clay and find the water in a sand bed beneath.

Sewerage—Nelsonville has a good system of sanitary sewers, but no storm drains. The surface water is carried through gutters and ditches to the old canal bed and to a small run which empties into the Hocking

river. There are five miles of sanitary sewers, which give about 75 per cent. of the population access to them. They have one outlet to the river one mile below town. On account of the remoteness of the outlet no complaint is made of the sewage, but it must be objectionable during periods of extremely low water. There are 300 connections to the sewers, one-half of which are for water closets and the rest for drains and sinks. Vault connections are not allowed to be made to the sewers. The construction and location of vaults is not regulated to any extent. They must be cleaned at least once a year, but in some cases they are covered over and new ones dug. Night-soil is buried in the country.

SPRINGFIELD, Clark county, population 47,000. This city, the county seat of Clark county, has all the modern improvements except a good sewer system, something which is lacking in most Ohio towns. Three large private homes are located here. The principal industries are the large reaper and thresher works.

Water Supply—The water works were put in by the city in 1881, and have cost to date $666,402. The first supply was from a filter gallery; this soon failed and two years later a reservoir was built just above the junction of Beaver and Buck creeks at the site of the present pumping station. This reservoir is 350 feet long, 200 feet wide and 18 feet deep, giving a capacity of about 8,000,000 gallons. The bottom and sides are only graveled and badly covered with weeds and moss. The reservoir is filled by the seeping in of the ground water. In order to raise the level of the ground water and keep the reservoir full, a dam was built about 300 feet below the junction of the creeks. This dam is 50 feet long, four feet high and backs the water up past the reservoir. This reservoir and the old gallery supplied the city until 1894–95, when the new station and gallery was put in and the old station abandoned. The new gallery is 200 feet long, 32 inches wide and 48 inches high and lies 20 feet below the surface in an extensive gravel bed, which is situated under and between the two creeks at their junction. The gallery leads to a covered pump well 30 feet in diameter and 21 feet deep. This gallery supplies an excellent water and so far plenty of it. The reservoir is connected to the pump well by a 36-inch main, to be used in cases of emergency only.

The old station contains a 2,500,000-gallon Cope and Maxwell pump that can be used to pump the water from the old gallery to the new pump well in case of failure of the new supply due to continued drought. The new station contains a horizontal, compound, duplex Holly pump of 5,000,000 gallons capacity and a vertical, triple expansion Allis pump of 7,000,000 gallons capacity. The Holly pump was brought from the old station, but has been remodeled, and is in good condition now. The

are in use and 150 of these metered. The average daily consumption is 3,000,000 gallons and the average per consumer is 150 gallons.

The annual water rates are as follows:

Private houses, three rooms or less	$3 75
" " each additional room	62½
" bath tube, each	2 50
" water closets, each	2 50
" stables, per stall	1 25

Meter rates per 1,000 gallons:

Three hundred and eighty-five thousand gallons or less per year	16
Three million gallons or over per year	8

It is estimated that 50 per cent. of the city's population use well water for domestic purposes. The wells in the low portion of the town are all dug and only 20 feet deep, while those on the hills are drilled and 60 feet deep. The shallow wells obtain their water from gravel beds and the deep ones from sandstone. A private company furnishes spring water to a portion of the city.

Sewerage—Akron has the combined system of sewers, with three outlets to the Little Cuyahoga river, two below town and a temporary one above. Much of the storm water, however, is carried off by surface drains, making the system almost a sanitary one. There are 32 miles of sewers in, giving some 40 per cent. of the population access to them. It is claimed that there are 3,000 connections to the sewers, but this figure is much too high. The sewage during extremely dry weather causes a nuisance on account of the small volume of the river. There is a dam five feet high and 50 feet wide in the river between the sewer outlets, but as the upper outlet brings in but little sewage, it causes no trouble. Vaults must be water-tight or dry earth closets used. Night-soil is disposed of on the neighboring farms.

BELLEVUE, Sandusky and Huron counties, population 4,149. Bellevue lies both in Sandusky and Huron counties. It is a manufacturing town of growing importance. Three railroads pass through it. The principal industries are the large plow and cultivator works. It has many well paved streets, electric lights and a water supply.

Water Supply—The water works were put in by the corporation in 1874, and have cost to date $100,000. The supply is from a well and a county ditch. The supply at first was from the ditch alone. This was impounded in a small reservoir five acres in area and having a capacity of 35,000,000 gallons. In 1881 an additional reservoir was built; this one has an area of eight acres and a capacity of about 55,000,000 gallons. These reservoirs have earthen embankments, but seem to be in good con-

dition. The ditch which runs through them is fed by the farm tile and small ditches. It has a watershed of 2,000 acres, consisting of well farmed land, and the pollution consists of the drainage from the large rural population and from highly manured fields.

The well is 204 feet deep and 10 inches in diameter; it was drilled in 1895. It goes through limestone all the way, the water coming from numerous crevices found at all depths. The water stands 90 feet below the surface in summer and 65 feet below in winter. The level is influenced but little by the pumping. The well is pumped by a Downy deep-well pump of 375,000 gallons capacity. The suction is 146 feet below the surface, to which depth the water can be pumped. As the well water is hard, its use is objected to by the large number of boiler users. The manufacturing interests are strong here, so the well water is used only in the summer when the reservoirs are low, though it is much the better water from a sanitary standpoint. The reservoirs flow to a pump well 15 feet in diameter and 20 feet deep, from which the water is pumped to a standpipe by two pumps, one a Gordon pump of 1,500,000 gallons capacity and the other a Knowles pump of 500,000 gallons capacity, both in poor condition. The standpipe is 20 feet in diameter, 100 feet high and has a capacity of 230,000 gallons. There are nine miles of mains in, giving 75 per cent. of the population access to the water. There are 480 services in use, none of which are metered. The average daily consumption is 500,000 gallons and the average per consumer is 175 gallons. A great deal of this water can be accounted for by the fact that three railroads are supplied from the city mains.

The annual water rates are as follows:

Private houses, six rooms or less	$5 00
" " each additional room	50
" bath tubs, each	2 00
" water closets, each	2 00
" stables, one horse and carriage	2 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	25
One thousand to 2,000 gallons per day	15
Two thousand to 4,000 gallons per day	10

The city water is not used to a very great extent for domestic purposes; nearly every house has a private well for drinking water. Most of these are about 35 feet deep and dug into the limestone for a few feet, where the water is found. Filtered cistern water is also used.

Sewerage—Bellevue has a unique method of disposing of sewage. Some 50 to 60 feet down there seems to be an underground stream or

vein of considerable size, which is said to come to the surface at Castalia, north of there. Down to this current, wells or sinks are drilled into which all sewage and a great deal of the storm water is emptied. There are a number of these holes drilled by the city for street drainage and many more drilled by private parties to dispose of sewage. As it costs a good deal to drill these sink holes, most of the private houses use vaults. None of these are water-tight. Night soil is buried in the country.

CANTON, Stark county, population 51,826. Canton is the county seat of Stark county. It is quite a manufacturing city, iron and clay being the principal products. But besides these industries there are the two large watch factories, employing some 1,800 hands.

Water Supply—The water works were put in by the city, and have cost to date $400,000. The supply is obtained from the west branch of Nimishillen creek and from wells. Canton has had a water supply for many years, the first water being taken from the Nimishillen creek, which was the sole source of supply until 1888, when the first wells were put down, nine being added in 1898

Nimishillen creek is dammed 1.3 miles above the pumping station, and the water brought down by a small race or canal. This dam is 35 feet long and only one foot high, merely diverting the water to the race. The creek at this point has a watershed 48 square miles in area. The only source of pollution is from the numerous farm houses and barn yards, and from a public ford one-fourth mile above the dam. Stock of all kinds are washed and watered at this ford, seriously contaminating the public water supply. The water is badly discolored at times from the large amount of organic matter due to leaves, etc.

Twenty-six drilled wells were put down in 1888 in the park adjoining the pumping station. In 1893 these were supplemented by six wells built along the race. These latter supply now more water than all the rest. The 26 wells are each four inches in diameter, and six six inches in diameter, all averaging 270 feet in depth. These wells go through on an average of eight feet of soil, 260 feet of limestone and then into sandstone.

A 2,000,0 0-gallon Gordon pump, put in in 1889, pumps the wells to a large pump well. The water rises very near the surface when the wells are not pumped, and is leveled about 25 feet by direct suction. During a test some of the wells were lowered 60 feet. The race water also empties into the common pump well, and both waters are then pumped direct by the following pumps: A 3,000,000-gallon Worthington, erected in 1887, and a 2,500,000-gallon Worthington, put up in 1890, also a 7,000,000-gallon Holly, put in about 1892. These pumps are all horizontal, compound, duplex, and are in fair condition. The average daily consumption is 3,687,781 gallons, allowing a reasonable slip for the pumps. Of this

about 1,200,000 gallons is supplied by the wells, and the rest is the raw water from Nimishillen creek. This water is improved some by subsidence in the race. The public water is accessible to 90 per cent. of the city's population. There are 4,000 services, of which only 20 are metered. The average daily consumption per capita for the population actually supplied is 135 gallons.

The water rates are as follows:

Private houses, four rooms or less	$5 00
" " each additional room to six	1 00
" " each additional room above six	50
" water closets, each, with house use	2 00
" " " " without house use	5 00
" stables, one horse and cow	1 00

Meter rates per 1,000 gallons:

Five hundred to 1,000 gallons per day	15
Two thousand to 3,500 gallons per day	10
Ten thousand to 20,000 gallons per day	6

There are not many private wells in the city; most of these are dug and average 60 feet deep, getting their water from gravel.

Sewerage—The separate system of sewers is used. There are eight storm sewer outlets, three to the West Branch of the Nimishillen, four to the East Branch and one to Shivers run, which empties into the East Branch. There are 9.36 miles of storm sewers, which, with the creeks and run, take care of all the storm water.

The sanitary or house sewers all lead to one trunk sewer, which carries the sewage to a sewage disposal works south of the city. There are 17.32 miles of these sewers, including two-thirds of a mile of trunk sewer leading to the disposal works. About 50 per cent. of the city's population have access to the sewers. There have been some 1,300 connections made, but this is an estimate only, as no record is kept.

The average amount of sewage to be disposed of is 1,600,000 gallons. This is treated in a chemical precipitation plant, consisting of four tanks, each 100 by 50 feet in area, with the necessary channels, wiers, etc., and a large house for the pumps, chemical tanks, etc. As the sewage passes through this machinery house, one grain of alum and 10 grains of lime are admitted in solution to the sewage for each gallon of the same. The sewage then flows through the tanks in succession, depositing all its impurities, coming out of the last tank a comparatively clear liquid, with a slight milky tinge. This effluent flows into the Nimishillen creek but causes no nuisance. When enough sludge has collected on the bot-

tom of the tanks the water is drawn off and the sludge run to a sludge well, from which it is pumped to a filter press. The sludge is used for fill or disposed of to the farmers. The sewage plant has cost $31,464.62 to date. The running expenses for the last year were $3,128.45 or $5.35 per 1,000,000 gallons of sewage treated.

Vaults are being done away with; none are allowed to connect with sewers. No new ones are built in the heart of the city, but many old ones still exist. Of course the outskirts still build vaults and build them according to their own ideas and plans.

COLUMBUS, Franklin county, population 140,000. Columbus, the capital of the State, is the third city in point of size. It contains several large State institutions, including the State University, which give it a large unproductive population. Its commercial and manufacturing interests are not small, however. The principal industries are the several large buggy factories, shoe factories, steel plant, engineering works and a large amount of general manufacturing. It once rightly claimed the best paved streets and handsomest residences of any city in the State, but the former have sadly deteriorated. It has a good sewer system, but is troubled at present with the disposal of the sewage, as the Scioto river and Alum creek can no longer furnish water enough for the dilution method, which has always been used. A new water supply, or rather an addition to the present system is under consideration.

Water Supply—The water works were put in by the city in 1871, and have cost to January 1, 1898, $2,294,341.35. The original supply was from a filter basin near the Olentangy river, at its junction with the Scioto. This furnished the supply until 1877, when, to meet the increased demands of the city, the construction of a filter gallery was commenced. This gallery consisted of an open work brick tunnel 3½ feet inside diameter and 5,715 feet long. It passed under the Olentangy river six feet below its bed, thence along the Dublin pike to the Scioto river at the site of the present intake, one mile west of the pumping station. This gallery gathered its water from the extensive gravel beds underlying this section of the country. The gallery was completed in 1880, and in 1883 more water being required, a branch gallery was started and completed in the following year. This branch, 1,650 feet long, was of the same construction as the main conduit; it started from a point in the main gallery just under the Scioto river and extended under the Big Four and B. & O. railroads. In 1885 a similar gallery was run from the same point in the main conduit due north 1,931 feet. It was soon found that these galleries would not furnish enough water and new ones were proposed, but there was no urgent need at that time, owing to the completion

of the new East Side station in 1891. The supply from this station was first obtained from one large brick well 26 feet in diameter and originally 58 feet deep, but since filled up by the infiltration of sand. The supply from this well soon failed to meet the growing demand, and, in 1894, 32 wells were driven in a six-acre field bordering on Alum creek. These wells are 60 feet deep and six inches in diameter, all connected up to a common suction pipe, which is attached to a 36-foot suction pipe from the main well.

The wells go through the various layers of soil, clay, etc., down to 40 feet, at which depth a layer of hard-pan is passed through below which is water-bearing gravel, more hard-pan is passed through and a second large water-bearing stratum is found just above a layer of hard-pan at 60 feet, to which the wells go. The casing is perforated at the bottom and at the 40-foot level, so as to get water from both strata. The suction of the pumps is 20 feet below the surface, and when not pumping the water rises above this point. The supply has always been sufficient and even large demands lower the water but little. Owing to the distance of some of the wells from the pumps and long suction, a vacuum pump is necessary to keep the air out of the suction pipe leading to the wells. Until 1898 the above sources attempted to supply the city, but with less success each year. During all this period more or less water had to be taken direct from the Scioto river at a point just one mile west of the pumping station. The river at this point receives no pollution from the sewage of the city, except the overflow from the insane asylum sewer as explained in Professor Brown's report. The stone quarry settlements near Marble Cliff furnish a very objectionable surface drainage. The sewage from the Girls' Industrial Home, Marysville, Marion and Kenton finally reaches the Scioto, but at such distant points that the river loses all visible signs of it but does not, from a chemical and bacteriological standpoint, completely recover.

In 1898 a new gallery was constructed starting at the station and extending under the Olentangy river, along the Dublin pike, and then under the Scioto river, in all 3,550½ feet. This gallery was constructed of a 42-inch cast iron pipe, with the lower half perforated for the admission of water. Along this line, and flowing to it, 34 6-inch wells, averaging 70 feet deep, were drilled to augment the supply. These wells extend down through the gravel and about 10 feet into the limestone under it.

Plans are proposed for a large storage reservoir on the Scioto river, with small temporary dams below it, which can be filled during low water from the large reservoir, and thus always keep water in the river, from which the galleries under the latter are to be supplied. During the winter of 1898 after the new gallery and wells were connected up, there

was but little need for the direct connection to the Scioto, and the city was furnished with the subsurface water for a greater part of the time.

At the end of 1897 there were 171.5 miles of mains in use, giving about 90 per cent. of the population access to the water. There are 12,892 services in use, of which 3,005 are metered. The average daily consumption for the West Side station was 7,689,472 and for the East Side 5,806,362, making a total of 13,495,834 gallons, or an average per consumer of 160 gallons.

The annual water rates are as follows:

Private houses, one family, four rooms or less	$2 66
" " each additional room	66
" bath tubs, hot, each	2 66
" water closets, each	2 00
" stables, one horse and carriage	2 33

The meter rate is six cents per 1,000 gallons.

There has been a good deal of objection to the city water for the last few years and many will not drink it without previously boiling or filtering. A much too large percentage of the people use private well water. These wells are of every kind and depth, some shallow dug wells 15 to 20 feet deep, others drilled wells 100 or more feet deep. Most of the well water shows more or less direct sewage contamination and should not be used.

Sewerage—Columbus has the combined system of sewers with outlets to Alum creek and to the Scioto river. The sewage from the eastern part of the city is collected by a trunk sewer, which empties into Alum creek just south of Main street. This outlet causes a terrible nuisance during summer and fall, when the creek contains but little water.

The sewage from the main portion of the city, just east of the Scioto and Olentangy rivers, is carried to an intercepting sewer running the whole length of the city, and emptied into the Scioto opposite the southern part of the city. This interceptor has 22 storm overflows to the two rivers, six of which are to the Olentangy above the water works. The "West Side" has two sewers, one emptying into the Scioto just above Mound street and the other opposite the mouth of the interceptor below. The first sewer is the outlet for the oldest system of Columbus and drains the portion of the West Side just west of the river. The other sewer is what is known as the "Dry Run sewer," about which there is litigation at present. The city has been enjoined from allowing closet connections to be made to this sewer, and the outcome of the controversy is uncertain. The two large asylums in the western part of the city have a force-main to the Scioto river at Mound street, through which they pump their sewage. The sewers emptying into the Scioto cause a nuisance of

the foulest kind during dry weather. The water works takes all the summer flow of the river, thus making that below town nothing but pure sewage.

In all there are 143.59 miles of public sewers, 10 miles of private sewers, giving 80 per cent. of the population access to them. It is estimated that 75 per cent. of those having access to the sewers are connected, or 60 per cent. of the total population.

Vaults, hand flush closets, water closets, everything are allowed to connect to the sewers, which account for the large percentage above. Vaults are constructed in any and in every manner, and but few are water-tight. Night-soil is disposed of in the country. Garbage is collected and hauled to a disposal plant near Alum creek, where the grease, etc., are extracted, and the refuse used for fertilizer. There is a great deal of local complaint about this plant, not much of which is well founded.

HARRISON, Hamilton county, population 1,816. Harrison lies bot in Ohio and Indiana, the above population is for both towns, as the water supply is in common. The village has no paved streets or sewers.

Water Supply—The water works were put in by a private company in 1891. The same company also owns the electric light plant. The combined cost of both plants was $54,300, of which about $12,000 can be charged to the light plant. There has been $2,200 added to the water plant.

The company operates under a 20-year franchise, granted in 1891, with no provision for purchasing by the village and nothing regarding the kind of water to be supplied.

The supply is from Whitewater river and wells. Most of the water comes from the river, as the wells cannot supply enough. The only chance of pollution to the river is the small village of New Trenton, six miles above, and the usual number of farm houses. The water is pumped direct from the river through two 10-inch intake pipes. There are four driven wells eight inches in diameter and 18 feet deep in the bottom of a pump well 16 inches in diameter and 18 feet deep. The wells obtain surface water only from a large gravel bed.

There are two pumps in use, one attached to the well and one to the river intake. These pumps are of the horizontal, duplex Gordon type and have a capacity of 5,000,000 gallons each. The water is pumped to a standpipe, which is 110 feet high and 14 feet in diameter with a capacity of 125,000 gallons.

There are four miles of mains, giving about 50 per cent. of the people in both towns access to the water. There are 150 services in use, of which

25 are metered. The average daily consumption is 35,000 gallons and the average per consumer is 40 gallons.

The annual water rates are as follows:

Private houses, one or two rooms, one family	$3 00
" " three or four rooms, one family	4 00
" " nine or ten rooms, one family	8 00
" " each additional family	2 50
" bath tubs, each	4 00
" water closets, each	4 00
" stables, one horse and carriage	3 00

Meter rates per 1,000 gallons:

One thousand gallons or less per day	24
" to 2,000 gallons per day	18
Over 10,000 gallons per day	10

The private water supply is principally from drove wells, 20 to 35 feet deep, which get their water in a bed of gravel.

Sewerage—There are no sewers, either public or private, that have closet connections. The storm water is drained to Whitewater river. As the construction of the vaults is not regulated in any manner, most of them are merely holes in the ground, while a few are either boarded or bricked up.

MARION, Marion county, population 16,484. Marion is the county seat of Marion county. It has electric lights and cars, paved streets, a water supply and a fair sewer system. Its industries consist of a steam shovel, agricultural and traction engine works.

Water Supply—The water works were put in by a private company in 1890, and have cost to date about $240,000. The franchise is for 25 years, and the city may purchase the plant 10 years from November 23, 1888, and every five years after this period. The following section of the franchise refers to the kind of water to be supplied: "The supply shall be ample for all the wants of a place of 20,000 inhabitants. It shall be a good potable water, free from all obnoxious and injurious elements, and be procured from such suitable places as will guarantee its present purity, and the source shall be protected from future encroachment or pollution." The present supply is from a basin and wells two miles west of town, near the Little Scioto river. The original supply was from the basin, the wells being put down in 1895 to help through the dry months. The basin is an irregular shaped canal in the old bed of the Scioto river and gets its water from the gravel beds of the river, springs and some surface drainage. It has an area of 1½ acres and the water is from six to eight feet deep in it, giving a capacity of about 2,000,000 gallons. The sides and

bottom are the natural clay and gravel and they become very badly overgrown with weeds.

There are 10 wells in a double row 600 feet long, five of these are 200 feet deep, one 140 feet, one 120 and three 100 feet deep, all are eight inches in diameter. Only two of the wells are connected to the pumps. When the reservoir gets low the two wells are pumped to it by two small Worthington pumps, one attached to each well. These pumps are horizontal, simple pumps, one of small capacity.

The water stands in the wells 12 feet below the surface when not being pumped, and is lowered the suction limit. The water is pumped from the reservoir to a standpipe by two horizontal, compound, duplex Dean pumps of 1,500,000 gallons capacity each. The standpipe is 25 feet in diameter and 90 feet high, with a capacity of 332,000 gallons.

There are 15 miles of mains, giving 75 per cent. of the population access to the water. There are 887 services in, 737 of these being in use and 70 metered. The average daily consumption is 550,000 gallons and the average per consumer is 125 gallons.

The annual water rates are as follows:

Private houses, five rooms or less	$5 00
" each additional room	1 00
water closets, each	4 00
bath tubs, each	4 00
" stables, one horse and carriage	8 00

The meter rates per 1,000 gallons per day for the first 1,000 is 25 cents, and for each additional 10 per day is 10 cents.

There are a large number of private wells in use, many are shallow dug wells getting a surface water above the limestone, the drilled ones are 45 to 65 feet deep and get a good water in the rock.

The sewerage of Marion has been previously reported on, and will be found on page 145 of the General Report.

MASSILLON, Stark county, population 14,328. Massillon is on the line of the Ohio canal, which gave it its original prosperity. The principal industries are agricultural works, glass factories, a rolling mill and paper mill. The paper mill manufactures a great deal of strawboard and discharges its refuse into the canal, discoloring it for a long distance. The new State hospital for insane is located about one-half mile south of the city; it has just been dedicated and has but few patients. It will have its own water works and sewage disposal plant. Massillon has some paved streets, sewers and a water supply.

Water Supply—The water works were put in in 1881 by a private company, operating at first under a franchise granted in 1881, but now under one granted June 7, 1886. This latter contract has the following clause in it regarding the kind of water to be supplied:

"The water is to be taken from Sippo lake, which is to be thoroughly cleaned and such precautions taken as will prevent future contamination, and be conducted from the lake to an impounding reservoir similarly prepared and protected. From the reservoir the water shall be first filtered and be led through a 24-inch main to the pumping station of the company, from which it will be pumped into a standpipe or reservoir of sufficient capacity and elevation to at all times supply all parts of the city with water."

The city has the option of purchasing the plant at the end of 10 years and of every five year period thereafter.

The supply is at present taken from two sources. The water used for domestic purposes is taken from a gang of drilled wells, while the water for manufacturing purposes, street sprinkling, etc., is taken from a reservoir supplied by Sippo lake.

There are six wells, six inches in diameter, with an average depth of 200 feet, the lower part in sandstone. Four of these wells flow when not being pumped and in the other two rises very near the surface; during pumping the water is lowered 15 feet The wells are pumped direct by a 2,000,000-gallon Blake pump, put in in 1887, and by a 1,500,000 Dean pump and a 1,000,000-gallon Worthington pump, both put in in 1893, when the wells were first used. A small reservoir, 18 feet deep and 30 feet in diameter, holding 100,000 gallons is used as a reserve supply for the wells. The water is pumped from the wells to a standpipe, which was erected in 1883, being used formerly on the old supply. It is 25 feet in diameter, 150 feet high and has a capacity of 550,000 gallons. There are 24 miles of mains in this, the high pressure system, giving some 75 per cent. of the population access to the water. There are 1,300 services in use, 50 of which are metered. The average daily consumption is 500,000 gallons, allowing slip on the pumps This gives an average daily consumption per consumer of 65 gallons, which is an important figure, as it represents the amount of water used for domestic purposes only.

The low pressure supply is by gravity from a large reservoir supplied by Sippo lake, a large marshy district northeast of the city. This supply was secured in 1881 and supplied the city for all purposes until the wells were introduced in 1893. A 2,000,000-gallon Blake pump stands in an old pumping station, which can still be used to pump the lake water to

the standpipe in cases of great emergency. The low pressure is 25 pounds and the high pressure is 75 pounds.

The annual water rates are as follows:

Private houses, five rooms or less	$5 00
" " each additional room	75
" bath tubs, each	2 75
" water closets, each	3 00
" stables, one horse and carriage	2 50

Meter rates per 1,000 gallons:

One hundred to 200 gallons per day	25
One thousand to 2,000 gallons per day	18
Over 5,000 gallons per day	15

There are but few private wells in use; these are drilled wells from 20 to 30 feet deep and go into gravel and sand above the bed rock.

Sewerage—The combined system of sewers is used. The lateral sewers empty into an intercepting sewer, which has its outlet into the Tuscarawas river, just south of the city; the storm water overflows are to the canal. The sewers are accessible to about 20 per cent. of the people and about 40 per cent. of this number are connected, or about 150 families. The sewage causes a nuisance in the dryest weather, owing to the small flow of the river, but on account of the location of the outlet, the objection is not great.

Nearly every house in town has an outdoor vault, very few of which are water-tight.

NILES, Trumbull county, population 4,694. Niles is situated on the Mahoning river, a few miles above Youngstown, with which it has electric car connection. As with its neighboring towns, the iron industry is large. There is one paved street, a short sewer and a water works.

Water Supply—The water works were built by the city in 1891 and have cost to date $65,000. The supply is from nine wells driven in the low land near the river, with direct connection to the latter for use in case of fire. The wells intercept the underdrainage of the city on its way to the river and they may obtain a polluted water as the city grows. They are eight inches in diameter and from 50 to 75 feet deep, going through sandy loam and hard-pan into gravel in which the water is found. The wells flow when not being pumped, but the water can easily be lowered to the suction limit of the pumps, to which they are attached direct. The water is pumped to a covered reservoir by two horizontal, duplex, compound Hughes pumps of 1,200,000 gallons capacity each, both put in with the works. The reservoir is cut into the natural sandstone lined with brick

in cement and is covered with a shingle roof. It has a capacity of 1,250,000 gallons.

The wells fail to supply water for fire purposes and a 14-inch pipe has been run to the river which must be used on such occasions, and it is said to be used occasionally at other times. There are 10 miles of mains in giving some 70 per cent. of the population access to the water. There are 559 services in, of which 555 are in use and none metered. The average daily consumption is 421,000 gallons and the average per consumer is 120 gallons.

The annual water rates are as follows:

Private houses, six rooms or less	$6 00
Each additional room up to 10	1 00
Private bath tubs, each	3 50
" water closets, each	3 00
" stables, one horse and carriage	3 00

One-half of the city's population drink well water. The wells are mostly shallow dug ones very liable to pollution.

Sewerage—Niles has 1,000 feet of combined sewers with an outlet to the Mahoning river. This sewer is on the main street and has some 50 water closets connected with it. There is a private sewer, with 10 connections, in an addition north of town, which empties into Mosquito creek, a tributary of the Mahoning.

Vaults are not regulated in any way. Night soil and garbage are disposed of individually on the neighboring farms. There is a dam three feet high and 200 feet wide on Mosquito creek, which backs the water up some three miles. It runs a local flour mill.

RAVENNA, Portage county, population 3,484. This is a quiet country village with but little manufacturing. It has a water works, electric lights, but no sewers. It is now paving the principal street.

Water Supply—The water works were put in by the village in 1885 and have cost to date $125,000. The original supply was from Crystal lake. This soon failed in summer and in 1888 connection was made to Mussy lake. This supply was unsatisfactory, and in 1895 four wells were put down near Crystal lake. Crystal lake has an area of 37 acres and Mussy lake an area of 75 acres and an average depth of 30 feet. The drainage of the surrounding country finds access to these lakes but the pollution is not serious. Mussy lake is said to furnish the poorer water of the two and objection was made to using it as a source of supply for Ravenna. There are three wells six inches in diameter and one four inches in diameter and they are 192, 281 and 152 feet deep respectively. The wells go through clay and gravel striking the sandstone 140 feet from the surface. The

wells are pumped by a Pohle air-lift to Crystal lake when the latter is low, usually from June 1 to January 1. When not being pumped the water stands 26 feet below the surface and can be lowered 60 feet. The water is pumped direct from Crystal lake to the mains by two horizontal, compound, duplex Knowles pumps of 1,500,000 gallons each. Mussy lake was formerly pumped to Crystal lake by a 1,000,000-gallon Knowles pump, which is still in place near the lake. There are 18 miles of mains in, which give some 90 per cent. of the population access to the water. There are 1,100 taps or faucets in use on the mains, but no record is kept of the number of services. There are 14 meters in use. The average daily consumption is 500,000 gallons.

The annual water rates are as follows:

Private houses, five rooms or less	$5 00
" bath tubs, each	2 00
" water closets, each	2 00
" stables	2 00

Meter rates are five to 15 cents per 1,000 gallons according to the quantity used.

The private water supply is from a few dug wells about 20 feet deep. This water is used a good deal in summer for drinking, as the public supply is warm.

Sewerage—The drainage of Ravenna is west to the Cuyahoga and east to the Mahoning river. There are two storm sewers in town, one emptying into each of the above rivers, or into ditches leading to them. There are one or two closets connected to these sewers, which cause some nuisance in summer. A few water closets are drained to cesspools. The majority of the people use outdoor vaults or dry earth closets.

WOOSTER, Wayne county, population 5,956. Wooster, the county seat of Wayne county, is a quiet, aristocratic city, with but little manufacturing, its life being influenced to some extent by the small university located here. There are a number of well paved streets which are kept in good condition. It also has a sewer system and a water supply.

Water Supply—The water works were put in by the city in 1875 and have cost to date $114,000. The supply at present is obtained from two sources. The first water was supplied by gravity from the Redick reservoir, which is formed by a dam across Christmas run in the northern part of the city. The run above the dam has a drainage area of eight square miles, on which are located a number of farm houses and the County Children's Home, which has some 60 inmates. This institution has no sewer system, depending upon outdoor vaults. All surface drainage,

however, enters Christmas run, then flows down to the reservoir, only three-fourths of a mile below. The reservoir will hold 8,000,000 gallons, with an average depth of 18 feet. Its sides are paved roughly, but no provision is made to keep the mud from the hills from washing in. The water is very muddy all the time and it is covered with scum and growths to some extent. Besides the surface water the reservoir is supplied by a few small springs. Christmas run is dry most of the time and the reservoir is filled during freshets, when the water is in the worst condition. A well was drilled above the reservoir some years ago and pumped to the reservoir, but this stopped all the springs, so this was abandoned. As the reservoir is only 114 feet above the streets the need of greater pressure and also of a larger supply was soon felt. In 1881 a well, 47 feet deep and 33 feet in diameter, was dug northeast of the city, and the Bloomington reservoir built. The well is now pumped to the reservoir by a three-fourths million gallon Worthington pump put in in 1888. When not being pumped the well has 13 feet of water in it and it is pumped dry in about five hours, then allowed to fill again. The reservoir is circular, four acres in extent, and holds 4,000,000 gallons of water, with a depth of 13 feet. The sides of the reservoir are paved roughly, no surface drainage can enter it. Its edges are overgrown with weeds and the bottom is covered with moss. The reservoir is 160 feet above the pumping station and 248 feet above the city streets. The average daily consumption is 500,000 gallons, about half of which is supplied from each reservoir. There are 11¼ miles of mains, to which some 80 per tion per consumer is 220 gallons. This means but little, as the city water cent. of the city's population have access. There are 485 services of which 367 are in use and 128 of these metered. The average daily consump- is but little used for domestic purposes.

The annual water rates are as follows:

Private houses, five rooms or less	$4 00
Each additional room	50
Private bath tubs, each	2 00
" water closets, each	2 50
" stables	3 00

Meter rates per 1,000 gallons:

One thousand gallons or less per day	10
Over 1,000 gallons	08

The domestic water supply is obtained almost entirely from private wells. Nearly every house in town has a dug well, these are 18 to 25 feet deep in the lower portion of the town and some deeper back on the hills.

There are about 35 drilled wells in use, these run from 40 to 100 feet deep. The water is found in shale, which starts just below the surface and extends some distance below the wells. Vaults are not allowed within 50 feet of a well unless water-tight, but most of them are not tight and the subsurface water is of doubtful purity.

Sewerage—The combined system of sewers is used, with one outlet to Apple creek just south of the city. About 60 per cent. of the population have access to the sewer and there are 300 vaults and water closets connected to them. No complaint is made of the sewage, but the outlet is so far removed that none would be made even if the sewage were objectionable.

The stream above the sewer is periodically flushed by the operation of a water power above the outlet. The dam is 30 feet long and six feet high and is used to run a small grist mill. The water is collected by the dam and allowed to escape in volume during the operation of the mill, washing the sewage into Killbuck creek.

4. SUBSURFACE AND DEEP-SEATED WATER SUPPLIES.

The report upon the supply of Wapakoneta is included with the special report upon the Maumee watershed.

EATON, Preble county, population, 3,892. Eaton, the county seat of Preble county, is a country village with no public improvements except its water works.

Water Supply—The water works were put in by the village in 1891, and have cost to date about $80,000. The supply is from wells and springs near Seven Mile creek. The well water is furnished by 10 driven wells ranging from 74 to 89 feet in depth and all six inches in diameter. They go through 55 feet of hard-pan into a bed of gravel which furnishes the water. The wells flow when not being pumped, and the water can be lowered 35 feet during dry weather. The springs are one-fourth mile west of the water works at the foot of a hill just across Seven Mile creek. The water is collected by a sewer pipe gallery and is brought by gravity through a tile to the station. Near the works this pipe line empties into a silt well, 13 feet in diameter and 15 feet deep, which frees the water from the heavier sediment before it reaches the pumps. It is estimated that the wells can supply 150,000 gallons per 24 hours, and the springs 200,000 gallons. A covered reservoir of 100,000 gallons capacity is just being built, into which the water of the wells and springs may flow when the pumps are not running. The reservoir is 110 feet long, 12 feet wide, 12 feet deep and will be built of brick laid in cement. Direct connection can be made to the creek for use in case of fire. The water is pumped to a standpipe by three pumps, two are horizontal, compound Gordons of 1,000,000 gallons capacity each and one small Hughes pump of 500,000 gallons capacity. The first pumps were put in with the works, and the latter in 1898. The standpipe consists of a tank 20 feet in diameter and 80 feet high, placed on top of a stone tower 50 feet high. It has a capacity of 185,000 gallons.

There are nine miles of mains in, giving some 75 per cent. of the population access to the water. There are 390 services in use, of which 110 are metered. The average daily consumption is about 90,000 gallons per day, and the average per consumer is 40 gallons.

The annual water rates are as follows:

Private houses	$5 00
" bath tubs, each	2 50
" water closets, each	2 00
" stables, one horse and cow	3 00

Meter rates per 1,000 gallons:

One hundred to 500 gallons per day	25
One thousand to 2,000 gallons per day	15
Two thousand to 4,000 gallons per day	12½

The private water supply is from shallow wells 18 to 20 feet deep. The water is usually found in gravel, but in the western part of the city limestone is struck.

Sewerage—The storm water is drained to Seven Mile creek by gutters and ditches. There are no sewers in use. There are three water closets which drain to cesspools. Night-soil is hauled to the country. A sewer system will be necessary as several gutters are in bad shape from accumulated filth.

5. DEEP-SEATED WATER SUPPLIES.

Only one town was examined having a public water supply in this class, and this one was, only because it formerly had a surface supply.

SIDNEY, Shelby county, population 5,777. Sidney, the county seat of Shelby county, has a number of small industries. It has electric lights and a water supply, but no paved streets or sewers.

Water Supply—The water works were put in by the village in 1874. The old plant cost $50,000 and the new one put in in 1889 has cost to date $107,500. The first supply was from Mosquito creek. This was abandoned in 1889, and water was taken from the Miami river. The water was filtered through two American pressure filters of 225,000 gallons capacity each and later a New York horizontal pressure filter of 500,000 gallons capacity was put in. In 1895 wells were drilled and water enough to supply the town found. Now these form the sole source of supply, and the creek water is not used at all, though the intake is intact and the water could be drawn on in case of emergency. The filters were also put out of use as soon as the well supply was developed. The present supply is from six wells, 120 feet deep and eight inches in diameter, located near the pumping station. The wells are all artesian and flow at the rate of 1,000,000 gallons in 24 hours during favorable seasons and are only lowered 10 feet by the pumps. They go through a bed of gravel 20 feet thick, then strike the Niagara limestone, in which the water is found, which is of excellent quality except for its hardness. The water is pumped direct from the wells to a standpipe situated on a hill back of town. The two pumps in use are vertical, compound, duplex Gordon pumps of 1,500,000 gallons capacity each and put in in 1889. The standpipe is 25 feet in diameter, 86 feet high and has a capacity of 300,000 gallons. It gives a pressure of 70 pounds at the station.

There are 13 miles of mains in, giving some 90 per cent. of the population access to the water. There are 700 services in, of which 685 are in use and 52 of these metered. The average daily consumption is 600,000 gallons and the average per consumer is 150 gallons.

The annual water rates are as follows:

Private houses, nine rooms or less	$5 55
Each additional room	55
Private bath tubs, each	2 22
" water closets, each	2 22
" stables, one horse and carriage	3 33

Meter rates per 1,000 gallons:

One hundred to 1,000 gallons per day	$0 25
One thousand and over gallons per day	20

The tap water is used for domestic purposes whenever available. The private water supply is from shallow driven wells.

Sewerage—There are only two sewers in town, one from the court house and neighboring streets, and one from the local brewery, both emptying into the Miami river. There are but few connections to the sewers, they are used for storm water principally.

There is a dam below town, which backs the water up past the sewers and prevents the sewage from getting away. At times this causes a nuisance. Vaults are not regulated and but few are water-tight. Night soil is hauled out on the farms.

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ERRATA.

Page 24, line 4, read *corrections* for *connections.*

Page 83, line 5, read *turbidity for urbidity.*

Page 86, line 35, read *rumors* for *rumor.*

Page 88, 4th line from bottom, comma for period.

Page 88, last line but 1, read *as* for *a.*

Page 89, line 1, read *surface* for *face.*

Page 93, last line, read 8.384 for 8384.

Page 100, 4th line from bottom, insert "*of November*" after "*month.*"

Page 116, 16th line from bottom, *River & Gallery* read *River, Well, and Gallery.*

Page 137, 21st line from bottom, *drained* read *dammed.*

Page 146, 12th line from bottom, *is* read *are.*

Page 152, 6th line from bottom, *fu* read *full.*

Page 154, 10th line from top, 35 read .035.

Page 162, 11th line from bottom, *is six* read *is lowered six.*

Page 173, 3d line from top, *supplies* read *supplied.*

Page 173, 5th line from top, *supplied* read *supplies.*

Page 175, 7th line from bottom, *and* read *as.*

Page 178, Title 1, *Subsurface* read 1, *Surface.*

Page 182, 6th line from top, .87 read .107.

Page 182, 7th line from top, .87 read .087.

Page 184, 14th line from top, *has* read *have.*

Page 188, 3d line from bottom, 209 read 20.9.

Page 197, 10th line from bottom, 45 read 4.5.

Page 199, 4th line from bottom, *one of the* read *the one.*

Page 201, 13th line from top, *water yet, well* read *water, yet well.*

Page 219, 14th line from top, 646 read 64.6.

Page 223, 18th line from top, 4383 read 438.3.

Page 227, 10th line from bottom, 84 read 8.4.

Page 244, 7th line from top, *leakings* read *leachings.*

Page 257, 8th line from top, *one* read *both.*

Page 257, 16th line from bottom, *per day for the first* 1,000 read *for the first* 1,000 *gallons per day.*

Page 257, 15th line from bottom, 10 *per day* read 1,000 *per day.*

Page 262, 5 lines, beginning line 17 from bottom, should read: *There are* 11¼ *miles of mains to which some* 80 *per cent. of the city's population have access. The average daily consumption per consumer is* 220 *gallons. This means but little, as the city water is but little used for domestic purposes. There are* 485 *services, of which* 367 *are in use and* 128 *of these metered.*

Page 265, 2d line from bottom, *will be* read *will soon be.*

3 2044 103 127 528